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WATER QUALITY INVENTORY AND MANAGEMENT PLAN

LOWER YELLOWSTONE RIVER BASIN

MONTANA

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WATER QUALITY BUREAU
ENVIRONMENTAL SCIENCES DIVISION
Montana Department of Health and Environmental Sciences

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WATER QUALITY INVENTORY AND MANAGEMENT PLAN
LOWER YELLOWSTONE BASIN, MONTANA

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CONTENTS

Page

LIST OF TABLES v

LIST OF FIGURES viii

I. INTRODUCTION. 1

II. RELATED INVESTIGATIONS AND PLANS. 4

BASIN-WIDE WATER QUALITY RELATED STUDIES 4

BASIN-WIDE WASTE TREATMENT MANAGEMENT PLANS. 6

III. BASIN PHYSICAL CHARACTERISTICS. 7

GENERAL FEATURES. 7

CLIMATE. 9

SOILS 11

LAND USE. 14

WATER USE 15

POPULATION AND ECONOMICS. 17

BASIN HYDROGEOLOGY. 19

IV. MONTANA WATER POLLUTION PROGRAM 24

INTRODUCTION. 24

STATE AND FEDERAL WASTE DISCHARGE PERMIT PROGRAMS 24

WATER QUALITY STANDARDS. 27

STATEWIDE MONITORING AND SURVEILLANCE PROGRAM. 28

FACILITIES, CONSTRUCTION, OPERATION AND MAINTENANCE. . . 28

PUBLIC PARTICIPATION. 29

ENFORCEMENT. 30

Page

V. WATER POLLUTION SOURCES 31

GENERAL 31

MUNICIPAL DISCHARGES 31

Baker 32

Belle Creek 32

Broadus 33

Fairview 33

Fallon 33

Glendive 34

Lambert 34

Miles City 34

Plevna 34

Savage 35

Sidney 35

Terry 35

West Glendive 35

MUNICIPAL WATER TREATMENT PLANTS 36

Glendive 36

INDUSTRIAL DISCHARGES 36

Holly Sugar Corporation 36

Montana-Dakota Utilities Steam Generating Plant - Sidney 39

Montana Dakota Utilities Steam Generating Plant-Glendive 39

Sidney Rendering Company 40

Miles City Packing Company 40

Miles City Sand and Gravel Company 40

Rahr Meat Company at Glendive 40

Page

Gary Operating Company - Belle Creek. 40

Shell Oil Company - Cabin Creek. 40

Union Texas Petroleum Company - Belle Creek. 43

Union Texas Petroleum Company Light Ends Refinery near Baker. 43

AGRICULTURAL WASTE DISCHARGES 43

NON-POINT SOURCES. 43

VI. SURFACE WATER RESOURCES. 47

GENERAL FEATURES. 47

YELLOWSTONE RIVER SUB-BASIN - TONGUE TO POWDER RIVERS. . 50

LITTLE POWDER RIVER SUB-BASIN. 50

POWDER RIVER SUB-BASIN. 50

O'FALLON CREEK SUB-BASIN. 51

YELLOWSTONE RIVER SUB-BASIN - POWDER RIVER TO STATE LINE. 51

VII. SURFACE WATER QUALITY. 54

GENERAL FEATURES. 54

YELLOWSTONE RIVER SUB-BASIN - TONGUE TO POWDER RIVERS . . 59

LITTLE POWDER RIVER SUB-BASIN. 63

POWDER RIVER SUB-BASIN. 63

O'FALLON CREEK SUB-BASIN. 75

YELLOWSTONE RIVER SUB-BASIN - POWDER RIVER TO STATE LINE. 75

MUNICIPAL LAGOON DISCHARGES. 87

SUMMARY. 91

VIII. BIOLOGICAL CONDITIONS. 96

IX. MANAGEMENT STRATEGY AND PLAN 98

X. MONITORING AND SURVEILLANCE 103

XI. COAL DEVELOPMENT. 106

Page

XII. BASIN WATER QUALITY PROBLEMS AND FUTURE NEEDS. 107

REFERENCES. R-1

APPENDIX

APPENDIX A. SYSTEM FOR GEOGRAPHIC LOCATION OF FEATURES. A-1

APPENDIX B. MONTANA WATER QUALITY STANDARDS. A-2

APPENDIX C. GLOSSARY. A-15

APPENDIX D. DISCHARGE PERMITS AND COMPLIANCE SCHEDULES (TABLE). A-16

LIST OF TABLES

Table		Page
1.	STREAMS SAMPLED IN THE LOWER YELLOWSTONE BASIN.	10
2.	MEAN AND EXTREME TEMPERATURE AND PRECIPITATION FOR WEATHER STATIONS IN OR NEAR THE LOWER YELLOWSTONE BASIN.	12
3.	MEAN MONTHLY TEMPERATURES AND MEAN MONTHLY PRECIPITATIONS AND ANNUAL AVERAGES FOR SEVERAL SELECTED WEATHER STATIONS IN OR NEAR THE LOWER YELLOWSTONE BASIN.	13
4.	COMMUNITIES OF 100 OR MORE PERSONS IN LOWER YELLOWSTONE BASIN	17
5.	POPULATION AND EMPLOYMENT IN LOWER YELLOWSTONE BASIN. .	18
6.	EMPLOYMENT BY GROSS SECTORS IN LOWER YELLOWSTONE BASIN	18
7.	CHEMICAL ANALYSIS OF GROUND WATER FROM VARIOUS SELECTED MUNICIPAL WELLS IN OR NEAR THE LOWER YELLOWSTONE BASIN.	23
8.	SUMMARY OF MUNICIPAL DISCHARGE INFORMATION	37
9.	SUMMARY OF MUNICIPAL DISCHARGE DATA.	38
10.	SUMMARY OF INDUSTRIAL WASTE INFORMATION.	41
11.	SUMMARY OF CONFINED FEEDING OPERATIONS IN THE LOWER YELLOWSTONE BASIN HAVING APPLIED FOR A WASTE DISCHARGE PERMIT OR RECEIVED	44
12.	SUMMARY OF IRRIGATION SYSTEMS IN THE LOWER YELLOWSTONE BASIN HAVING APPLIED FOR A WASTE DISCHARGE PERMIT. . .	45
13.	IDENTIFIED SALINE SEEP ACREAGE IN THE EIGHT MAIN COUNTIES OF THE LOWER YELLOWSTONE BASIN IN 1969 & 1973.	46
14.	SUMMARY OF SUB-BASIN SIZE AND STREAM FLOW FROM GAGED STREAMS IN THE LOWER YELLOWSTONE RIVER BASIN.	48
15.	SUMMARY OF THE MAJOR USGS WATER QUALITY AND CONTINUOUS DISCHARGE MONITORING STATIONS IN OR NEAR THE LOWER YELLOWSTONE BASIN	55

Table — Page

16. SUMMARY OF STREAM SAMPLING SITES IN THE LOWER YELLOWSTONE BASIN COLLECTED BY THE WATER QUALITY BUREAU IN 1973 AND 1974. 56

17. MEAN HIGH FLOW AND LOW FLOW VALUES OF COMMON WATER QUALITY PARAMETERS FOR SEVERAL WATER QUALITY SITES IN THE EASTERN PORTION OF THE YELLOWSTONE BASIN. 58

18. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE YELLOWSTONE SUB-BASIN - TONGUE TO POWDER RIVERS FIELD PARAMETERS. 60

19. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE YELLOWSTONE RIVER SUB-BASIN - TONGUE TO POWDER RIVERS COMMON CONSTITUENTS. 61

20. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE YELLOWSTONE RIVER SUB-BASIN - TONGUE TO POWDER RIVERS NUTRIENTS AND METALS. 62

21. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE LITTLE POWDER RIVER SUB-BASIN - FIELD PARAMETERS. 64

22. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE LITTLE POWDER RIVER SUB-BASIN - COMMON CONSTITUENTS. 65

23. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE LITTLE POWDER RIVER SUB-BASIN - NUTRIENTS AND METALS. 66

24. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE POWDER RIVER SUB-BASIN - FIELD PARAMETERS. 67

25. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE POWDER RIVER SUB-BASIN - COMMON CONSTITUENTS. 69

26. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE POWDER RIVER SUB-BASIN - NUTRIENTS AND METALS. 71

27. EFFECT OF THE POWDER RIVER ON DISSOLVED SOLID AND SUSPENDED SEDIMENT CONCENTRATIONS AND LOADING IN THE YELLOWSTONE RIVER FOR THREE FLOW REGIMES. 74

28. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE O'FALLON CREEK SUB-BASIN - FIELD PARAMETERS. 76

29. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE O'FALLON CREEK SUB-BASIN - COMMON CONSTITUENTS. 77

30. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE O'FALLON CREEK SUB-BASIN - NUTRIENTS AND METALS 78

Table | Page

31. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE YELLOWSTONE RIVER SUB-BASIN - POWDER RIVER TO THE MONTANA-NORTH DAKOTA BORDER - FIELD PARAMETERS. 79

32. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE YELLOWSTONE RIVER SUB-BASIN - POWDER RIVER TO THE MONTANA-NORTH DAKOTA BORDER - COMMON CONSTITUENTS. 81

33. CHEMICAL ANALYSIS OF WATER COLLECTED IN THE YELLOWSTONE RIVER SUB-BASIN - POWDER RIVER TO THE MONTANA-NORTH DAKOTA BORDER - NUTRIENTS AND METALS. 83

34. CHEMICAL ANALYSIS OF WATER COLLECTED FROM SEVERAL SEQUENTIAL SITES ON THE YELLOWSTONE RIVER DURING A WATER QUALITY RUN IN EARLY OCTOBER OF 1974. 86

35. MONTHLY MEAN WATER TEMPERATURES AND SPECIFIC CONDUCTANCES OBTAINED AT USGS SITES ON THE YELLOWSTONE RIVER NEAR MILES CITY AND SIDNEY. 88

36. CHEMICAL ANALYSIS OF WATER COLLECTED FROM VARIOUS LAGOON SYSTEMS IN THE YELLOWSTONE BASIN - FIELD PARAMETERS. 89

37. CHEMICAL ANALYSIS OF WATER COLLECTED FROM VARIOUS LAGOON SYSTEMS IN THE LOWER YELLOWSTONE BASIN - COMMON CONSTITUENTS. 89A

38. CHEMICAL ANALYSIS OF WATER COLLECTED FROM VARIOUS LAGOON SYSTEMS IN THE LOWER YELLOWSTONE BASIN - NUTRIENTS AND METALS. 90

39. SELECTED WATER QUALITY CRITERIA AND STANDARDS. 93

40. SUMMARY OF WATER POLLUTION PROBLEMS IN THE LOWER YELLOWSTONE RIVER BASIN 108

LIST OF FIGURES

Figure		Page
1.	SKETCH MAP SHOWING LOWER YELLOWSTONE RIVER BASIN	3
2.	SCHEMATIC DIAGRAM OF SURFACE WATERS IN THE LOWER YELLOWSTONE RIVER BASIN.	49
3.	AVERAGE MONTHLY DISCHARGE - POWDER AND LITTLE POWDER RIVERS	52A
4.	AVERAGE MONTHLY DISCHARGE - YELLOWSTONE RIVER AND BURNS CREEK.	53

WATER QUALITY INVENTORY AND MANAGEMENT PLAN FOR THE LOWER YELLOWSTONE BASIN IN SOUTHEASTERN MONTANA

I. INTRODUCTION

This report presents information relative to water quality and water quality inventory and management in the Lower Yellowstone Basin (Figure 1, Plate I). Also included is a description of the physical characteristics of the basin and a brief discussion of basin biological conditions. The objectives of this effort were to provide the state with water quality data and related information in order to:

1. determine the water quality characteristics of natural waters and wastewaters;

2. determine those factors, both natural and man-made, which affect the quality of water;

3. develop a management strategy for maintaining and enhancing the quality of waters in the basin;

4. and provide information needed to determine whether Montana's water quality standards are being met and will continue to be met.

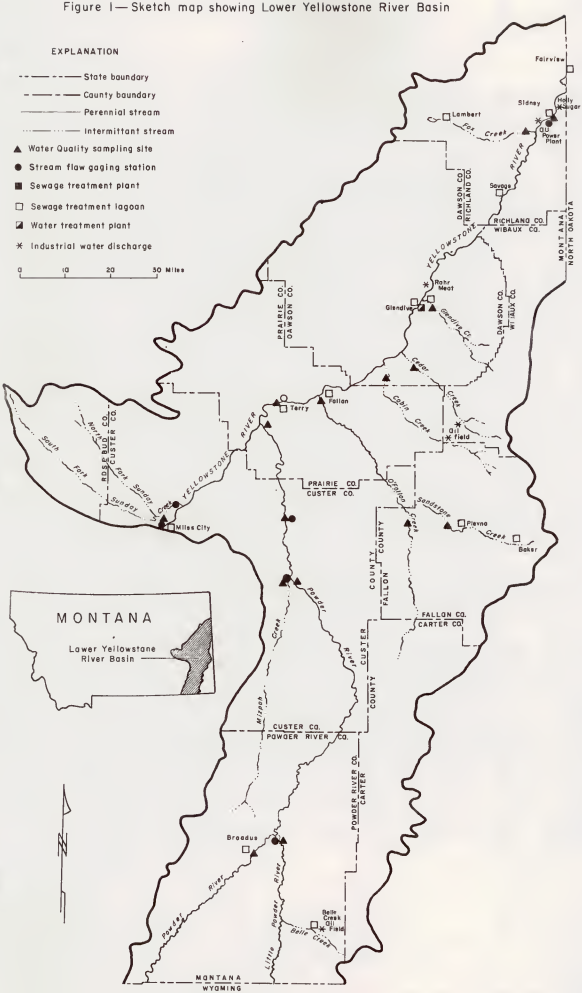
The Lower Yellowstone Basin is the lower or eastern portion of the total Yellowstone River Basin and is one of the sixteen basins designated by the State of Montana for the preparation of water quality management plans. The Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) have directed states to prepare such plans as a part of a nation-wide program for controlling water pollution.

The general methodology used in this study was first the compilation and evaluation of existing water quality data and related information. Secondly, where information was deficient, field investigations and water and wastewater sampling and analyses were conducted to obtain needed information. This report does not present a detailed analysis or inventory of the basin's resources but summarizes water quality related information. As additional information becomes available, the Lower Yellowstone Basin water quality management plan will be revised and updated as a part of Montana's planning process.

Assistance in obtaining information for this report was obtained from a number of agencies and persons. The Montana Department of Natural Resources and Conservation provided information on land use, water use, population and economy. The United States Geological Survey personnel

provided unpublished water quality and discharge data on stations maintained by their agency. Federal waste discharge permit information was obtained from Mr. Richard T. Montgomery, U. S. Environmental Protection Agency, State Engineer for Montana. Weather data was obtained from the U. S. Department of Commerce Weather Bureau. Thanks are also given to various individuals residing in the basin that supplied information pertinent to the study.

Figure 1—Sketch map showing Lower Yellowstone River Basin



II. RELATED INVESTIGATIONS AND PLANS

BASIN-WIDE WATER QUALITY RELATED STUDIES

A major ongoing study program in the Yellowstone Basin is the Northern Great Plains Resource Program (NGPRP) (Ref 1, 2). The aim of the Water Quality Subgroup of the NGPRP is to provide, in part, alternatives to the coal development patterns in southeastern Montana in relation to the area's water resources. Along with the assessment of available data, the NGPRP has also contracted with various federal and state agencies for the collection of additional water quality related data that this subgroup felt was necessary to achieve their goals. The agencies assessing the data and information for the Water Quality Subgroup are the U. S. Environmental Protection Agency (EPA), the U. S. Bureau of Sport Fisheries and Wildlife (BSF & W), and the U. S. Bureau of Reclamation (BuRec). The input of these agencies into the NGPRP is one of assessment only; the collection of data has been contracted out to other federal and state agencies. As examples, the United States Geological Survey (USGS), Water Resources Division, has received funding to establish new water quality and discharge monitoring stations in the Lower Yellowstone River Basin; the University of Montana at Missoula has been contracted to study the effects of in-stream flow variations on associated biological activity.

Several studies of a more general nature have preceded the efforts of the NGPRP. Important among these are the Missouri Basin Comprehensive Framework Study (Ref. 3) and the North Central Power Study (Ref. 4). The former broadly described the water quality and related resources of the entire Upper Missouri River Basin of which the Lower Yellowstone River Basin is a small part. The latter was a broad planning effort directed at coal development. It discussed coal resources, energy distribution, and potential pollution in southeastern Montana which includes a portion of the Fort Union and Powder River basin formations.

In addition to their involvement with the NGPRP, several additional studies are being completed by the BuRec in the region. They have recently published an aqueduct study (Ref. 5) and a report on the resources of basins in eastern Montana (Ref. 6). Within these reports, water quality and related resources are broadly outlined for the region. This agency has also initiated a total water management study for the Yellowstone River Basin. An analysis of the effectiveness of existing water use within the basin (which includes the Lower Yellowstone Basin) represents the initial phase of the study. As a part of this work, the State Water Quality Bureau (WQB), Montana Department of Health and Environmental Sciences, has contracted to assess certain water quality parameters on intakes from the Yellowstone River mainstem and from several of its tributaries that are used for irrigation.

Numerous studies by federal and state agencies are in progress in the adjacent Middle Yellowstone Basin to the west where extensive coal development is a more immediate prospect for the future, especially in the Colstrip area. Such studies, however, also involve or have some application to coal development in the Fort Union Formation in the Lower Yellowstone Basin. Several of these projects have been completed.

At the state level, of major interest is the effort of the Montana Department of Natural Resources and Conservation (DNR & C), Energy Planning Division; this agency has recently completed an impact study of the proposed electrical generating plants 3 and 4 at Colstrip (Ref. 7). Contracts for technical assistance were awarded to various state and federal agencies. Water quality assessments were conducted by the Water Quality Bureau. Several sites established for sampling of surface waters were located in the Lower Yellowstone Basin. The Montana Bureau of Mines and Geology has conducted groundwater sampling in the region. A fisheries biology study including benthic invertebrate surveys were completed by the Montana Department of Fish and Game. This agency has contracted with the USGS to supply a temperature model of the Yellowstone River from Billings to Sidney. The Montana Department of Intergovernmental Relations was asked to determine the additional needs for municipal water and sewer systems in the Yellowstone Basin. Effects on terrestrial vegetation and the likelihood of acid rain problems stemming from Colstrip emissions also were considered in a study conducted by the University of Montana. Montana State University also is involved in water quality related studies in the region, primarily in relation to reclamation of strip-mined spoils (Ref. 8, 9).

On the federal level, EPA has initiated a four year study of the environmental effects caused by trace elements from coal fired, power-generating stations. Tishler and Shaw (members of the NGPRP) are completing a report on the water requirements of generating facilities and on the water quality effects of spoil bank leachates. The Bureau of Land Management (BLM) is also involved in a number of projects including a study of the environmental impact of energy related developments on federal lands in the Yellowstone Basin. With the USGS, the BLM is assessing the water quality of wells in the Ashland region. With the U. S. Forest Service, the BLM is completing another interagency project, the "Birney-Decker Resources Study" (Ref. 10). The Bureau of Indian Affairs has solicited aid from the BSF & W and from a consulting firm for an impact assessment of coal and energy developments on the Crow and Northern Cheyenne Indian Reservations.

Several ongoing state and federal studies are more directly involved with the Lower Yellowstone Basin. The U. S. Department of Agriculture through the Surface Environmental and Mining Program (SEAM) has become involved in water quality related studies in the area. The National Commission on Water Quality has selected a reach of the Yellowstone River for detailed study and mathematical modeling. The Water Resources Division of the State DNR & C is currently developing a framework plan for Montana. The Lower Yellowstone Basin will be included in this plan. The Montana Department of Lands has initiated a study on the saline seep problem in Montana. The University of Montana has proposed a water

resources survey as a part of their RANN (Research Applied to National Needs) grant application; this study would include, in part, the Lower Yellowstone Basin. Finally, the Old West Regional Commission has awarded a contract to the State of Montana to assess the impact of coal development on the water resources of eastern Montana. The Lower Yellowstone Basin is included as a part of the region under consideration in the study. DNR & C is administering the contract and have funded several state agencies and universities for technical assistance on the project.

A private study has been undertaken by a consulting firm for the Intake Water Company of North Dakota. This study is directed at an assessment of water resources, quality and quantity, in the lower portions of the Yellowstone River basin. This company will use such information to determine the feasibility of diverting water from the Yellowstone River for use in various developmental schemes in and out of the State of Montana. For example, diversions at Intake, Montana for transfer to Beach, North Dakota have been proposed (Ref. 11).

BASIN-WIDE WASTE TREATMENT MANAGEMENT PLANS

The federal government has established a grant program to assist municipalities by providing a percent of the construction costs necessary to up-date or establish a community sewage treatment facility including outfall and interceptor sewers. Grants are processed through the State Department of Health and Environmental Sciences which has established municipal priorities for monies using a formula that followed federal guidelines. No communities within the Lower Yellowstone Basin have received grants under this program.

Construction grants for sewage treatment facilities awarded after July 1, 1974, come under a few federal grant program--Section 201 of the 1972 Amendment to the Federal Water Pollution Control Act. This requires that a municipality first submit a facility plan which is a series of alternatives that could conceivably meet the needs of the community. One is then chosen for its economic, engineering and environmental value. However, no communities within the Lower Yellowstone Basin have yet submitted such plans.

Section 208 of the 1972 Amendment provides for another planning program that involves area-wide waste management plans. This program attempts to involve county planning agencies and is a method of achieving land and water use planning as it influences water quality. The Montana Water Quality Bureau provides coordination for such 208 plans. A 208 plan is currently being developed that will include much of the Lower Yellowstone drainage basin.

Since there are no Indian reservations within the Lower Yellowstone Basin, construction grants for water and sewer facilities under PL 86-121 from the Public Health Service (administered by the Indian Health Service, Bureau of Indian Affairs) have no application to this region.

III. BASIN PHYSICAL CHARACTERISTICS

GENERAL FEATURES

The Yellowstone River Basin (Plate I and Figure 1) includes the Yellowstone River and all of its tributaries from Miles City, excluding the Tongue River drainage, to the Montana-North Dakota border. Five sub-basins have been designated within this river basin. The basins, together with their hydrologic designation are as follows:

1. The Powder River (42J) including Mizpah Creek.

2. The Little Powder River (42I).

3. O'Fallon Creek including its tributary Sandstone Creek (42L).

4. The Yellowstone River drainage from Miles City to its confluence with the Powder River (42K).

5. The Yellowstone River below its confluence with the Powder River including the tributaries of Cabin, Cedar, Glendive, Hay, Seven-Mile, and Fox Creeks.

With the exception of the Powder and Yellowstone Rivers, most streams in the Lower Yellowstone Basin are quite small and many have intermittent flow. With the exception of Baker Lake on Sandstone Creek, there are no large reservoirs in the basin, however, a dam near Moorhead on the Powder River in Montana has been proposed by the Bureau of Reclamation (Moorhead Dam). This dam was authorized in 1947 by Congress and is still under active consideration for construction.

The Lower Yellowstone Basin has a total area of about 11,650 square miles and is an area of rolling hills with gentle to moderate relief. The region is not typically mountainous and is sparsely forested. Big Sheep and Little Sheep Mountains are located at the northern border of the basin and form a hydrological boundary for the basin in this area. The Chalk Buttes are located to the east and separate the Lower Yellowstone Basin from the Little Missouri Basin in the southeastern corner of Montana. To the south there is mountainous terrain along the Powder and Little Powder Rivers. These mountains are the northeastern border of the Big Horn Mountains. The Montana/Wyoming border forms an artificial southern boundary for the basin while to the west the basin is bounded by the hydrological boundary between the Tongue and Powder River drainages.

Portions of ten counties in eastern Montana are included in the Lower Yellowstone Basin. These are:

COUNTY	PERCENT OF THE COUNTY IN THE BASIN	PERCENT CONTRIBUTION OF EACH COUNTY TO THE AREA OF THE BASIN
Carter	25%	7%
Custer	59%	19%
Dawson	81%	17%
Fallon	65%	9%
McCone	<1%	<1%
Powder River	61%	18%
Prairie	81%	12%
Richland	49%	9%
Rosebud	8%	4%
Wibaux	63%	5%

All surface waters within the Lower Yellowstone Basin have been classified by the Water Quality Bureau of the State of Montana (Department of Health and Environmental Sciences). The entire Yellowstone River mainstem within the basin and all of its tributaries with the exception of the Fox Creek drainage near Sidney have been designated as B-D_3. Fox Creek has been designated as a B-D_2 drainage. A B-D classification designates that the quality of water is to be maintained suitable for drinking, culinary and food processing purposes after adequate treatment (coagulation, sedimentation, filtration, disinfection, and any additional treatment necessary), bathing, swimming, and recreation. A B-D_3 designation further requires that the water is to be maintained suitable for the growth and propagation of non-salmonid fishes and associated aquatic life, plus waterfowl and furbearers. The more stringent B-D_2 (Fox Creek) designation requires that the waters be maintained suitable for the growth and marginal propagation of salmonid fishes and related fauna and flora. Detailed criteria for such classifications are given in Montana's Water Quality Standards (Appendix B).

Table 1 presents a list of the perennial or intermittent streams in the basin with a sufficient drainage area or flow to warrant the establishment of a sampling site and for which data is available. Also included in this table is the Department of Natural Resources' sub-basin designations for the streams, the drainage area of the sub-basins (Ref. 3), and the receiving waters of each stream. Streams of the Lower Yellowstone Basin have been designated as one segment by the State of Montana which has been classified as an effluent limited class segment. This classification indicates that water quality in the segment is meeting and will continue to meet applicable water quality standards after the application of effluent limitations as required by the Federal Water Pollution Control Act Amendments of 1972.

Twenty-eight water quality sampling sites were established by the Montana Water Quality Bureau on various streams in the Lower Yellowstone Basin to obtain needed water quality data for this plan. Streamflow measurements were obtained in conjunction with the water quality samples. Several sites were established by the Water Quality Bureau in conjunction

with the study of proposed Colstrip generating units 3 and 4 (Ref. 4). The USGS has six active, continuous-record gaging stations in the region. Of these, four sites on major streams are also monitored for water quality. The USGS site on the Little Powder River has been recently discontinued; some past water quality data, however, is available for this stream.

There are ten municipalities within the Lower Yellowstone Basin that are currently discharging to streams in the area. All of these are now under or liable to be under state discharge permits. In addition, two water treatment plants discharge in the basin. Only three municipalities do not have an effluent at the present time. One federal installation in the region is liable to be under a federal discharge permit. Also under or liable to be under state permits are thirty-four industrial discharges. Some of these relate to active operations in the various oil fields of the basin. In addition, thirty-two agricultural dischargers in the region will be liable to the state discharge permit program.

CLIMATE

The Lower Yellowstone Basin has a climate typical of the semi-arid Northern Great Plains region. Although counties of the basin are generally considered to be located in the "plains" region of Montana, this placement is made only in relation to the mountainous drainage basins to the west; in fact, many areas of the Lower Yellowstone Basin are quite hilly. Elevations commonly range from 2,000 to 3,500 feet with peaks up to 5,000 feet in elevation in parts of Powder River and Carter Counties. Orographic influences on climate are not as pronounced in this basin as they are in the state's western basins. Orographic influences are noted primarily to the south and east in the basin in Powder River, Carter, Fallon, and Wibaux Counties. In general, the Lower Yellowstone Basin has a continental climate characterized by relatively warm summers and dry, cold winters, variable rainfall, abundant sunshine through a large portion of the year, relatively low humidity, and distinct changes in daily and seasonal temperatures (Ref. 1-6).

Quite distinctive of this basin and the "plains" region in general is the marked seasonal variation in precipitation. During a normal year, 70 to 80% of the annual precipitation in the basin falls during the six-month, April-September growing season, primarily in the form of rain. June is typically the wettest month followed by May and July. Average annual precipitation most generally ranges between 12 and 14 inches with the higher terrains receiving the greatest amount of moisture (Ref. 1-6). However, precipitation of less than 12 inches per year is experienced locally (Ref. 2, 3). Also, precipitation exceeding 14 inches annually occurs in the hilly counties of the basin--15 inches in the eastern highlands of Wibaux County, 14 to 20 inches over the southern half of Carter County (especially along the higher ridges), and approaching 20 inches in the more mountainous areas of Powder River County. Both abnormally dry and abnormally wet

Table 1

Streams Sampled in the Lower Yellowstone Basin

Stream	Number of Sites Sampled	Sub-Basin Designation	Sub-Basin Area in Square Miles	Receiving Waters
Yellowstone River	5	42K-42M	6,173	Missouri River
Yellowstone River (above Powder)	1	42K	1,506	---
Sunday Creek	1	42K	------	Yellowstone River
Powder River	5	42J	3,273	Yellowstone River
Mizpah Creek	3	42J	------	Powder River
Sand Creek	1	42J	------	Mizpah Creek
Sheep Creek	1	42J	------	Powder River
Little Powder River	1	42I	650	Powder River
O'Fallon Creek	2	42L	1,553	Yellowstone River
Pennel Creek	1	42L	------	O'Fallon Creek
Sandstone Creek	1	42L	------	O'Fallon Creek
Yellowstone River (below Powder)	4	42M	4,667	Missouri River
Cabin Creek	1	42M	------	Yellowstone River
Cedar Creek	1	42M	------	Yellowstone River
Sevenmile Creek	1	42M	------	Yellowstone River
Hay Creek	1	42M	------	Sevenmile Creek
Glendive Creek	1	42M	------	Yellowstone River
Fox Creek	1	42M	------	Yellowstone River
Lonetree Creek	1	42M	------	Yellowstone River
TOTAL BASIN	28	---	11,649	---

years can occur within the basin, e.g., an extreme range of 6.1 to 22.8 inches at Miles City (Ref. 1, 2, 3). The typical 12 to 14 inch precipitation range would classify the basin as a semi-arid region; however, the relative abundance of rainfall during the summer growing season allows a successful and extensive dryland agricultural operation (Ref. 2). Only about one-fourth of the annual precipitation (primarily snow) occurs during the months of October to March. As a result, snowfalls in the basin are not typically heavy and annually average from 25 to 30 inches throughout most of the basin; higher values can be obtained from the hill areas (Ref. 4-6). For example, in Powder River County, mountains locally receive as much as 100 inches of snow (Ref. 3).

The average number of consecutive frost free days (temperatures greater than 32°F) from spring to fall (growing season) varies considerably throughout the basin in relation to latitude and altitude (Ref. 1-6). This parameter typically ranges from 110 to about 155 days with the longer "growing seasons" observed at the lower altitudes of the southern counties. In the northern counties, frost-free days range from 110 days in the hills to 130 days in the Yellowstone Valley. As noted, seasonal temperature variations around 32°F are quite marked in the Lower Yellowstone Basin. Extreme lows of less than -40°F and extreme highs greater than 100°F have been recorded for January and July respectively at various weather stations. Such extremes are seldom reached and are generally of short duration. More typically, average January low and average July high temperatures range from 2 to 10°F and from 85 to 90°F respectively. Average annual temperatures range from 41 to 46°F through most of the region, while daily changes in temperature can approach 30 to 40 degrees throughout the year.

Table 2 presents summarized data of various temperature and precipitation parameters for a number of locations throughout the Lower Yellowstone Basin. These particular sites were chosen in order to represent the various counties of the basin with their different geographical locations and features. Table 3 shows the mean monthly precipitation in inches, the mean annual precipitation in inches, the mean monthly temperature in degrees Fahrenheit, and the period of record in years for several weather stations in the basin (Ref. 7). The 1972 monthly means were adjusted for their departures from the normal. The basin range and mean values in Table 3 provide a fairly accurate picture of the basin climate (relatively dry with cold winters and warm summers) and of the seasonal changes in temperature and precipitation that occur in the region.

SOILS

Several soil groups are widely represented in the Lower Yellowstone Basin of Montana: (1) those developed in relation to water on alluvial fans, stream terraces and flood plains; (2) those developed on undulating to hilly sedimentary plains; (3) those developed on dissected and rough broken uplands; (4) those developed on smooth uplands; and (5) those developed on the glaciated plains. Erosion potentials on these soils range from slight to severe depending on type. Salt contents and runoff characteristics also vary with type (Ref. 1-7).

Table 2

Mean (Avg.) and extreme temperature and precipitation data for several weather stations in or near the Lower Yellowstone Basin (Ref. 1-6).

Site and County	Relative Basin Location	Years of Record	Temperature (°F) Daily Extremes	Temperature (°F) Annual Avg.	Temperature (°F) Jan. Avg.	Temperature (°F) July Avg.	Precipitation (inches) Annual Extremes	Precipitation (inches) Annual Avg.
Miles City-Custer	NW	--	-65-112	44.3	----	----	6.1-22.8	13.8
Glendive-Dawson	N-Central	80	-50-117	45.6	15.1	74.8	4.8-26.0	12.6
Richey-Dawson	N-Central	21	-43-107	41.8	11.3	69.7	8.3-20.8	13.2
Savage-Richland	NE	62	-53-111	43.4	13.3	71.0	5.9-27.1	13.9
Sidney-Richland	NE	30	-47-110	41.3	9.3	68.7	8.5-20.6	13.5
Wibaux-Wibaux	NE-Central	18	-55-110	41.6	----	----	12.1-21.3	15.0
Wibaux(2E)-Wibaux	NE-Central	12	-38-110	41.3	----	----	8.5-17.7	13.2
Plevna-Fallon	SE-Central	46	-52-111	43.2	14.5	----	6.7-22.6	13.4
Baker-Fallon	SE-Central	34	-------	----	----	----	7.7-24.4	13.3
Ekalaka-Carter	SE	52	-44-108	44.2	----	----	6.3-22.6	13.3
Boyes-Carter	SE	7	-40-105	44.0	----	----	9.4-19.6	14.0
Broadus-Powder River	SW	23	-42-108	45.1	18.0	71.0	7.9-21.9	14.0
Moorhead-Powder River	SW	9	-42-109	----	----	----	8.2-15.4	11.7
Sonnette-Powder River	SW	8	-38-105	----	----	----	8.4-16.1	11.9
Terry-Prairie	Near Central	19	-45-108	43.4	12.1	72.2	5.4-18.3	11.3
Mildred-Prairie	Near Central	50	-50-113	44.3	15.9	72.3	3.7-20.9	13.2

Table 3

Mean monthly temperatures and mean monthly precipitations and annual averages for several selected weather stations in or near the Lower Yellowstone Basin (Ref. 7).

Temperature (°F)

Site	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	Period of Record (Years)
Ekalaka	17.9	20.8	28.8	43.1	54.4	62.8	71.4	69.8	58.7	47.0	31.1	23.7	66-74
Glendive	15.2	18.7	30.5	46.5	58.4	66.3	74.7	72.0	60.8	48.8	33.3	22.6	72-80
Mildred	15.5	19.0	29.8	44.8	56.4	64.7	73.5	71.1	59.6	47.7	31.7	22.4	51-64
Miles City	16.5	20.3	30.9	45.7	57.4	65.6	75.3	72.6	61.0	49.0	32.6	23.2	35-35
Plevna	14.7	17.4	27.2	42.7	54.3	62.6	71.5	69.7	58.4	46.4	30.0	21.1	54-60
Savage	12.8	16.6	28.2	44.4	56.3	64.3	72.0	69.5	58.7	47.0	30.3	20.4	65-67
"Basin" Mean	15.4	18.8	29.2	44.5	56.2	64.4	73.1	70.8	59.5	47.7	31.5	22.2	
Range Max.	17.9	20.8	30.9	46.5	58.4	66.3	75.3	72.6	61.0	49.0	33.3	23.7	
Min.	12.8	16.6	27.2	42.7	54.3	62.6	71.4	69.5	58.4	46.4	30.0	20.4	

Precipitation (Inches)

													Average
Ekalaka	0.40	0.35	0.62	1.11	1.95	2.96	1.90	1.39	1.01	0.74	0.45	0.34	13.22
Glendive	0.39	0.39	0.62	1.03	1.60	3.17	1.73	1.48	0.90	0.71	0.41	0.30	12.73
Mildred	0.38	0.31	0.56	1.05	1.80	2.84	1.64	1.34	0.89	0.77	0.45	0.33	12.36
Miles City	0.44	0.37	0.65	1.06	1.73	2.71	1.34	1.24	0.96	0.87	0.43	0.37	12.17
Plevna	0.39	0.39	0.58	1.14	1.68	2.95	1.74	1.22	0.97	0.80	0.41	0.33	12.60
Savage	0.40	0.31	0.54	1.18	1.61	3.30	2.09	1.54	1.10	0.66	0.42	0.26	13.41
"Basin" Mean	0.40	0.35	0.60	1.10	1.73	2.99	1.74	1.37	0.97	0.76	0.43	0.32	12.75
Range Max.	0.44	0.39	0.65	1.18	1.95	3.30	2.09	1.54	1.10	0.87	0.45	0.37	13.41
Min.	0.38	0.31	0.54	1.03	1.60	2.71	1.34	1.22	0.89	0.66	0.41	0.26	12.17

Two of the listed soils present a slight to moderate erosion hazard. The soils on undulating to hilly sedimentary plains are deep to shallow loams, silt loams, silty clay loams, and sandy loams underlain by siltstones or weakly consolidated sandstones. These soils have a slow to medium runoff and therefore do not generally possess a high erosion potential. Similarly, soils of the smooth to rolling uplands are nearly level to rolling deep loams and clay loams underlain by a silty clay loam alluvium on sands and gravel. Again, runoff is reduced as reflected in the soil's minor erosion hazard. Salt does not generally pose a marked problem with these two soil types.

Two of the soils present a moderate erosion hazard in relation to the soil's composition and/or relief. The soils on alluvial fans, stream terraces, and flood plains are nearly level to sloping deep soils dominated by fine sandy loams, silt loams, and silty clay loams. These soils generally have a medium runoff and a correspondingly increased erosion potential. In addition, some of these soils are somewhat poorly drained, and have a high salt content. This is most marked on the flood plains. Soils of the glaciated plains also present a moderate erosion hazard. These soils are steep loams that are underlain by friable clay loam glacial till and silt loams that are underlain by silt loam sedimentary beds on uplands at the contact between the glaciated and sedimentary plains.

The most erodible soils in the basin are those on the dissected sedimentary plains and the rough broken uplands. These are generally moderately deep to shallow soils on hilly to very steep slopes. In these areas there are steep buttes that have exposed shale on broken slopes with walled drainage ways, flat divides, ridges and knobs. The area is drained by branching channels that are gullied at the headwaters. Soils are generally clays to silty clay loams which have a rapid runoff and provide conditions for severe erosion. This is evidenced in the high suspended solid content and turbidity of certain streams in the basin, e.g., the Powder River and Glendive Creek, which is most noticeable during spring runoff. Times required for the settling of the suspended particulates in stream samples is excessive due to their clayey nature. In addition to sediment, these soils have a high potential as a salt source to the streams. As a result, many of the streams directly draining the basin have high concentrations of dissolved and suspended minerals.

Soils in the Lower Yellowstone Basin are used for dryland and irrigated crops and ranges. Soils on flood plains, low terraces, fans, and footslopes are used for dryland crops with suitable areas under irrigation. Soils on uplands are used mainly for range with some gently to moderately sloping soils used for dryland crops.

LAND USE

The Lower Yellowstone Basin in Montana comprises an area of 11,650 square miles equivalent to 7,456,000 acres. Over 4.6 million acres of the area (62%) are rangeland and used for livestock grazing. Cropland

covers 1.1 million acres (15%) with only 12% (130,600 acres) of this cropland being irrigated (Ref. 1). Dryland crops include spring and winter wheat, barley, oats, corn and flax-reed. Irrigated crops include primarily hay and sugar beets with some dry beans and potatoes.

Approximately 38% of the basin is undeveloped or has non-agricultural uses. Of this total, about 14,000 acres are covered by small water areas with another 59,000 acres included in urban and built-up areas (Ref. 1). There are no Indian reservations in the lower Yellowstone region. Only 125,000 acres of the land is forest covered. Small portions of the Custer National Forest are located within the Lower Yellowstone Basin: to the southwest a small section in the Powder River drainage near Moorhead and to the east a small area along the Chalk Buttes near Ekalaka.

Other land uses include roads, railroads, mining development, and oil and gas exploration areas. Rather extensive oil fields are located along the Cedar Creek anticline from Glendive to Baker and in the Muddy Sands Formation of the Belle Creek region near Broadus. While much of the basin has large reserves of coal in the Fort Union Formation, only small areas are currently being mined. A small strip mine, located near Savage, supplies coal to the Montana-Dakota Utilities Company electrical generating plant at Sidney.

There are several relatively large communities within the Lower Yellowstone Basin. Miles City at the western edge of the basin and Glendive and Sidney further east are the largest cities in the region with populations of 9,073, 6,305 and 4,543 respectively (Ref. 2). These three communities along with several smaller towns are located along the Yellowstone River. Baker on Sand Creek is a major community to the east in the basin with Broadus on the Powder River serving the southern portion of the region. Plevna, Terry, Savage, and Fairview are examples of other small towns scattered throughout the area with populations ranging from near 50 to near 1,000 people; Baker has a population of 2,584 (Ref. 2).

WATER USE

The primary use of water in the Lower Yellowstone Basin is for irrigation to produce hay for livestock. A portion of the irrigation has been developed privately by individuals and small groups through the construction of diversions, small dams, and reservoirs. However, federal and state development projects have also provided facilities for the irrigation of land along the Yellowstone River (Ref. 1).

The major state project in the region was finished in 1938. At this time the Montana Water Resources Board completed construction on the Sidney pumping project which provides water to 3,200 acres of land near Sidney. The canals for this project and the construction of other small project reservoirs throughout the basin were financed by the Works Progress Administration (WPA) during the depression years.

The Bureau of Reclamation of the United States Department of the Interior has completed several irrigation projects in the region.

The Buffalo Rapids Irrigation project supplies water to over 25,000 acres of land along the Yellowstone River from Miles City to Glendive. This system begun in 1905, continues to expand as new land is developed along the river. The Lower Yellowstone project represents an eastern extension of the Buffalo Rapids system and provides irrigation water to 33,000 acres of land in Dawson and Richland Counties. The Intake Canal furnishes water to 800 acres of additional land above the Main Canal of the Lower Yellowstone Project. Another project, designed and constructed by the Bureau of Reclamation to serve the adjacent highlands, the Missouri River project, provides water to 2,300 acres of land in Richland County.

All of the projects previously listed withdraw water from the Yellowstone River for the irrigation of adjacent lands. In addition, there are some scattered patches of irrigated lands in the basin along the Powder River and Mizpah Creek (Ref. 3).

Annual diversion requirements for irrigation probably exceed three-fourths of a million acre-feet per year; consumptive use is estimated at only 185,000 acre-feet and return flows at 530,000 acre-feet per year. Most of this water is diverted from the Yellowstone River by the means of pump or gravity systems. Some groundwater is used, but not to any great extent (Ref. 1).

Rural water use approaches 424 million gallons per year (1,302 acre-feet) nearly all of which is derived from groundwater sources. Livestock water use is estimated at about one billion gallons per year (3,114 acre-feet) and is derived from both ground and surface water sources (Ref 1.).

Municipal water from public supplies totals near one billion gallons per year (3,250 acre-feet). There are nine towns which have public water systems using an average of 162 gallons per capita per day of water withdrawal. These towns are Baker, Broadus, Belle Creek, Fairview, Glendive, Plevna, Richey, Sidney and West Glendive. Two-thirds of the water is obtained from groundwater sources; only one community, Glendive, within the basin uses surface water from the Yellowstone River. They obtain 85% of their water from that source. The total population served by these systems approaches 18,000 people (1970 census figures)(Ref. 1). Miles City on the border of the Lower Yellowstone Basin also withdraws water from the Yellowstone River for municipal, consumptive use.

Self-supplied industrial water use accounts for up to thirty million gallons per day of withdrawal. The majority of this water comes from the Yellowstone River and is used nonconsumptively for cooling power generation plants at Sidney and Glendive (when operating). Consumption figures range from 200,000 to one million gallons per day (224 to 1,120 acre-feet per year) depending upon the rate of use and upon the purpose of the water withdrawn (Ref. 1).

Numerous water diversion and impoundment schemes have been proposed for the Lower Yellowstone Basin--primarily to provide water to coal development areas. One of the largest reservoirs proposed is Moorhead Dam on the Powder River just north of the Wyoming-Montana border in Powder River County, Montana. Other water development proposals include diversions from the Yellowstone River to provide water to areas in Montana and for export outside of the state. As an example, a proposed diversion is that of a subsidiary of Tenneco of Houston, Texas--the Intake Water Company. They filed an appropriation to divert about 80,000 acre-feet of water from the Yellowstone River at Intake, Montana to ultimately reach Beach, North Dakota (Ref. 4).

Water use in the basin will undoubtedly continue to grow as coal development for energy production becomes an increasingly larger user of the basin's water resources. With the small percentage of the cropland currently under irrigation, this water use is expected to increase also, primarily through the application of sprinkler systems using water from both surface and groundwater sources (Ref. 1).

POPULATION AND ECONOMY

This basin, lying in the far eastern part of Montana, contains parts of Powder River, Carter, Custer, Fallon, Prairie, Wibaux, Dawson, Richland, and Rosebud Counties. For this profile, 1970 census data from county census divisions have been summed to approximate the population and employment of the basin. According to the census, 1970 population of the basin was 35,712 with 19,871 classed as urban and 15,841 as rural. Communities considered urban by the census are Miles City, Glendive and Sidney. Communities with 100 or more people are listed in Table 4 with their 1970 population.

TABLE 4 . LOWER YELLOWSTONE BASIN
Communities of 100 or more persons

Community	County	1970 Population
Miles City	Custer	9,023
Glendive	Dawson	6,305
Baker	Fallon	2,584
Plevna	Fallon	189
Broadus	Powder River	799
Fallon	Prairie	200
Terry	Prairie	870
Fairview	Richland	956
Lambert	Richland	250
Savage	Richland	275
Sidney	Richland	4,543

Table 5 indicates a relatively stable population and employment picture, historically without impacts from coal development. This picture is

projected to continue. Mineral leases are currently held by a number of companies in the basin, but no plans are known for mining or processing the coal in the near future. If such activity occurs, it will increase at least employment to the extent that the requisite skills are not already available in the area. It will also increase population.

The gross sectors of employment shown in Table 6 indicate a service and trade oriented economy. Government at all levels is the largest service section, especially in the bigger communities. If coal development occurs, the mining and construction sectors will experience relative and absolute increases.

Agricultural employment has decreased gradually to about one-third of its 1930 level and can be expected to continue that decline, regardless of mining activity. Basin agricultural marketing receipts from livestock have been about twice those from crops in recent years.

TABLE 5. LOWER YELLOWSTONE BASIN - POPULATION AND EMPLOYMENT - Historical and Projected (1)

	1930	1940	1950	1960	1970	1980	1985
Population	36,441	32,659	35,055	38,550	58,712	37,116	37,289
Employment	14,623	10,376	13,201	13,038	13,385	13,392	13,436

(1) Based entirely on projection of historical data.

TABLE 6 . LOWER YELLOWSTONE BASIN - EMPLOYMENT BY GROSS SECTORS (1970 data)

Sector	Number	Percent of Total
Agriculture	2,733	20.4
Forestry & Fisheries	8	0.1
Mining	500	3.7
Construction	779	5.8
Manufacturing	510	3.8
Services & Other	8,857	66.2
	13,387(1)	100 percent

(1) Does not total 13,385 due to rounding.

BASIN HYDROGEOLOGY

Groundwater is extensively used in the Lower Yellowstone River basin, primarily for domestic and stock use, and to a lesser extent for irrigation and public water supply. Groundwater is a key factor in the development of the basin and is a critical resource in much of the stock and agricultural activities in the basin. As of January, 1970, 8,037 appropriations for wells and 2,011 appropriations for springs were on file with the Montana Bureau of Mines and Geology for the eight major counties of the Lower Yellowstone Basin (excluding Rosebud and McCone Counties) (Ref. 1, 2, 3). Of the 8,037 well appropriations in these counties, 5,132 were appropriated for stock use, 1,182 for domestic use, and 1,305 for both stock and domestic use; 225 appropriations were for irrigation, commercial-industrial, and other uses. The specific uses for 193 of these appropriations is unknown (2.4%). Stock and domestic uses totalled 95%. Of the 2,011 spring appropriations, 1,344 were appropriated for stock use, 7 for domestic use and 78 for stock and domestic use; 82 appropriations were for irrigation, commercial-industrial, and other uses. The specific uses for 500 of these appropriations is unknown (25%). Stock and domestic uses totalled 71% in the eight counties.

Since only portions of the eight counties are in the Lower Yellowstone Basin, the above figures overestimate the actual number of well and spring appropriations within this region. Based on land areas, it is estimated that 60% of the appropriated wells are actually in the Lower Yellowstone Basin. The remaining well and spring appropriations are located within the adjoining basins.

In Powder River County there is a near equivalency between groundwater appropriations and population (2,268 and 2,800, respectively) with one groundwater appropriation per 1.5 square miles (Ref. 3). In many areas of the basin, wells provide the only source of water. Many of these are private wells which provide water for homes, garden and stock use. In addition, a number of communities obtain their municipal supply of water totally from wells. This would include Plevna, Baker, and Broadus, all 50 to 100 miles south of the Yellowstone River, and all of the communities in Richland County--Crane, Lambert, Savage, Fairview, and Sidney. Along the Yellowstone River, Terry and Fallon use municipal groundwater supplies primarily for fire control (Ref. 2). Miles City has one well appropriated for public use to supplement the city's surface water supply from the Yellowstone River (Ref. 3). Municipal water in Glendive is obtained from both the Yellowstone River and from groundwater resources.

Several technical reports discuss the groundwater resources of the Lower Yellowstone Basins; these include Moulder (1953, 1958), Perry (1931, 1932, 1934, 1935), Peterson (1962), Taylor (1965, 1968) and Torrey (1951, 1956) (Ref. 4 to 14).

The availability, distribution, and quality of groundwater is directly related to the geological conditions within the basin. The geological history of the basin includes long periods of sedimentation with minor

interruptions by uplift and erosion. At the end of Cretaceous time (about 65 million years ago) a period of major structural upheaval created a structure called the Cedar Creek anticline, which trends northwestwardly across the northeastern half of the basin. Subsequent erosion has exposed older geological formations along the crest of the anticline. All rocks exposed at the ground surface in the basin are of sedimentary origin and range in age from Cretaceous (65 to 135 million years old) to Recent (less than 20,000 years old).

Geologic formations of importance to groundwater resources of the basin include alluvium of Recent age (less than 20,000 years old), the Fort Union Formation of Tertiary age (1 to 65 million years old), the Hell Creek, Fox Hills, and Pierre Formations of Cretaceous age. There are many thousands of feet of sediments that lie below the Pierre Formation, and some are known to be aquifers (water-yielding strata), but these zones are generally too deeply buried to be of significance in basin groundwater development. Alluvium of Recent and Pleistocene age is present along major streams in the basin. This alluvium is composed of a mixture of silt, sand, gravel and clay that range in thickness from a few feet to over 100 feet. The alluvium will yield moderate, and in some places large, amounts of water to wells. Quality of water from alluvium ranges from good to very poor. Along the Yellowstone River, terraces composed of sand, gravel, silt, and clay, are present. These terraces vary in thickness from a few feet to as much as a few hundred feet. Small to large quantities of groundwater are present in some terrace deposits, and the water is of a fair to poor quality.

Glacial deposits cover a considerable area along the Yellowstone River downstream from Glendive. These deposits consist of compacted mixtures of clay, silt, sand, gravel, boulders of limestone and other rocks. Extensive deposits of glacial material form rolling terrain that mantels higher terraces and upland areas on the northwest side of the river. The layer of glacial material generally is less than 10 feet thick and contains little groundwater. Sand and gravel-filled channels are present in the glacial deposits and where sufficiently thick, they often will yield adequate quantities of water to wells for domestic and stock use. The quality of water in such glacial channels ranges from fair to poor.

The Fort Union Formation of Tertiary age directly underlies alluvial and glacial deposits or is exposed at the ground surface over much of the basin. The Fort Union Formation in this portion of Montana is generally considered to be composed of three members--the Tullock Member, the Lebo Member, and the Tongue River Member. This formation where unaffected by erosion, ranges in thickness from 1,000 to over 2,000 feet. The Tullock Member is the lowermost or base of the Fort Union and consists of several hundred feet of light colored claystone, sandstone and coal beds. The Lebo Member consists of several hundred feet of shale and generally contains little or no groundwater. In many portions of the basin, the contact between the Lebo and the Tullock Members is gradational and is difficult to distinguish. Overlying the Lebo Member is the upper or Tongue River Member of the Fort Union Formation. The Tongue River Member,

where not reduced by erosion ranges from about 1,000 to 1,800 feet thick. This portion of the Fort Union Formation is lighter colored and more sandy than the lower members. Commercial beds and lenses of coal are common in the Tongue River Member. Most wells drilled 150 to 300 feet into this member obtain adequate water for domestic and stock purposes, and the quality is generally poor to fair. Coal beds in the Tongue River Member often supply water to wells.

Underlying the Fort Union Formation and exposed at the ground surface along both flanks of the Cedar Creek Anticline and along the Powder River west of Ekalaka is the Hell Creek Formation of Cretaceous age. The Hell Creek consists of about 500 feet of brownish-gray clay, dark shale, mudstone and sandstone. The Hell Creek Formation ranges in thickness from 200 to 500 feet. The lower portion of the Hell Creek Formation commonly is a sandstone that will normally yield abundant quantities of soft water for stock and domestic use. Locally, the water may be highly mineralized.

Beneath the Hell Creek Formation lies the Fox Hill Sandstone of Cretaceous age. The Fox Hills is exposed at the ground surface as narrow strips along both flanks of the Cedar Creek anticline. The Fox Hills generally ranges from 100 to 200 feet in thickness and is composed of sandstone and shale layers. The Fox Hills, where it is not buried too deeply, is widely used as a source of water in southeastern Montana. This formation generally will furnish small to moderate quantities of soft, moderately mineralized water. Toward the North Dakota border, the Fox Hills contains more shale and less sandstone and water quality and yield of water become poorer as the amount of shale increases. Beneath the Fox Hills Sandstone is a thick sequence of sedimentary formations which are generally too deeply buried to be of significance in the groundwater resources of the basin. The quality of groundwater from selected communities in the basin is shown in Table 7.

In some areas, groundwater levels have declined (Ref. 2); the possibility of overuse and wasting of water from aquifers constitutes a conservation problem for the future (Ref. 15). To avoid this, further detailed hydrogeological studies will be required to accurately assess groundwater resources in the counties of the basin and to assist these counties toward an orderly, proper, and efficient development of such resources. This will probably lead to the establishment of additional controlled groundwater areas in the Lower Yellowstone Basin similar to the one now located in Dawson County (Ref. 2).

Groundwater pollution is present in some areas of the Lower Yellowstone River Basin. Probably the most severe groundwater pollution problem in the basin is saline seeps, which occur in small to moderately sized areas in many portions of the basin, particularly north of the Yellowstone River between Glendive and the North Dakota state line. Saline seeps are created when precipitation infiltrates into salt-laden earth materials, thereby dissolving salt and subsequently redepositing the salt in areas of groundwater discharge. This is a serious problem in Montana and in the basin but has not to date, been thoroughly investigated.

Sewage stabilization lagoons generally have seepage into the groundwater and create localized areas of groundwater pollution; however, there have been no problems due to lagoon seepage reported from the sewage lagoons in the basin. Wastes from septic tanks can create localized areas of groundwater pollution where there a large number of septic tanks and individual water supplies using wells. Groundwater pollution can occur if disposal systems and wells are not properly designed and located. There have been no specific problems of this type identified in the basin.

Table 7

Chemical analysis of ground water in mg/l from various selected municipal wells in or near the Lower Yellowstone Basin. (Source: State Department of Health and Environmental Sciences, Helena, Montana.)

Location	Ca+Mg	Total Hard.	Na+K	HCO_3 $-CO_3$	SO_4	Cl+F	Fe	Total Solids*
Fairview	57	200	409	714	461	9.9	0.90	1290
Fairview	101	306	235	662	243	12.8	2.40	898
Sidney	116	374	99	396	232	13.2	0.50	670
Sidney	160	506	130	430	384	19.0	0.15	950
Sidney	91	247	109	323	183	19.7	0.00	520
Richey	14	45	475	1141	0	78.5	0.00	1170
Glendive	0	0	317	616	151	7.7	0.00	770
Glendive	0	0	390	857	85	36.8	0.00	970
Wibaux	13	46	476	629	488	10.5	0.14	1270
Wibaux	0	0	488	759	354	27.5	0.40	1300
Wibaux	184	580	246	677	498	23.3	2.15	1280
Miles City	11	40	327	777	49	29.3	0.00	854
Baker	0	0	328	549	220	15.6	0.15	870
Baker	9	25	179	292	127	10.5	0.07	470
Plevna	0	0	280	513	105	36.8	0.08	690
Plevna	0	0	252	454	129	15.8	0.11	560
Broadus	4	10	255	384	225	11.7	0.30	660
Broadus	0	0	175	226	154	25.5	0.00	420
Ekalaka	7	20	276	440	206	7.2	0.20	745
Ekalaka	0	0	202	421	74	5.4	0.55	480

*Total dissolved solids determined by evaporation

IV. MONTANA WATER POLLUTION CONTROL PROGRAM

INTRODUCTION

Water quality management planning is part of a broad, comprehensive water pollution control program administered by the Water Quality Bureau of the Environmental Sciences Division of the Montana Department of Health and Environmental Sciences. Details of this program are described in annual reports of the bureau. Important elements of the state program are:

1. State and federal waste discharge permit programs.
2. Water quality standards.
3. Statewide monitoring and surveillance.
4. Facilities construction grants, plan review, operation and maintenance inspections, training and licensing of operators.
5. Public participation.
6. Enforcement.

STATE AND FEDERAL WASTE DISCHARGE PERMIT PROGRAMS

The present state program of issuing waste discharge permits is operated under the authority given by the Montana water pollution control law and the Montana Pollutant Discharge Elimination System (MPDES). At the present time, the U. S. Environmental Protection Agency (EPA) is also issuing waste discharge permits in the state of Montana to federal facilities and to discharges, from other than incorporated communities, on Indian reservations. The permits are being issued pursuant to the National Pollutant Discharge Elimination System (NPDES) created by the Federal Water Pollution Control Act Amendments of 1972 (FWPCAA of 1972). To eliminate the duplication of effort which formerly existed, the state of Montana applied for and received authority from EPA to issue NPDES permits in Montana. Section 402

of the FWPCAA of 1972 provides that states with adequate water pollution control programs may apply for and receive authority from EPA to issue discharge permits under the NPDES in their own states. Montana made the necessary revisions to the state water pollution control laws during the 1973 legislative session to provide statutory authority for administration of the NPDES program in Montana. The Montana Department of Health and Environmental Sciences was given the authority to administer the waste discharge permit program on June 10, 1974. Waste discharge permits issued under the NPDES prior to the MPDES permit program will serve as MPDES permit until their date of expiration, (Appendix D). All MPDES permits issued meet the minimum requirements of the EPA for NPDES permits.

The Federal Water Pollution Control Act Amendments of 1972 established the following time schedule for upgrading waste treatment facilities:

MUNICIPALITIES

1. Secondary treatment by July 1, 1977.
2. Best practical control technology by July 1, 1983.
3. No discharge of pollutants by 1985 (goal)

INDUSTRIES

1. Best practicable control technology by July 1, 1977.
2. Best available control technology by July 1, 1983.
3. No discharge of pollutants by 1985 (goal).

NATIONAL SECONDARY TREATMENT REQUIREMENTS (FWPCAA OF 1972)

Minimum five-day biochemical oxygen demand (BOD_5) reduction to 85 percent.

Minimum suspended solids reduction of 85 percent.

Maximum effluent BOD_5 of 30 mg/l on monthly average and 45 mg/l on weekly average.

Maximum effluent suspended solids of 30 mg/l on monthly average and 45 mg/l on weekly average.

Maximum effluent fecal coliform of 200 organisms/100 ml on monthly average and 400 organisms/100 ml on weekly average.

pH limits on effluent maintained between 6 and 9.

Self-monitoring of these parameters is required. The frequency of monitoring is based on the population served and the complexity of the treatment facility and is stated in the NPDES or MPDES permit. In addition, some municipal dischargers are limited for and required to monitor effluent oil and grease.

WATER TREATMENT PLANT TREATMENT REQUIREMENTS

There are no parameters specified by the FWPCAA of 1972 to be monitored for water treatment plant discharges. The following requirements are being placed on NPDES permits issued in Montana:

1. No change in operating procedures will be allowed that would result in a less desirable discharge.

2. As soon as practicable but no later than July 1, 1977:

Total suspended solids (TSS)	$<$45 mg/l weekly average $<$30 mg/l monthly average
Total dissolved aluminum	1.0 mg/l monthly average $<$1.5 mg/l grab sample
pH	Maintained between 6.0 and 9.0

INDUSTRIAL BEST PRACTICABLE CONTROL TECHNOLOGY REQUIREMENTS (FWPCAA OF 1972)

Industrial waste dischargers will be required to provide the best practicable control technology currently available in treatment of their waste discharges. The parameters will be limited and monitored, and the frequency of monitoring will vary with the different types of industries. The specific parameters to be limited and monitored and the frequency of monitoring are stated in the NPDES or MPDES permit.

AGRICULTURAL TREATMENT REQUIREMENTS (FWPCAA OF 1972)

Federal regulations require that any animal confinement facility which on any 30 days during the previous twelve months contained 1,000 or more animal units must apply for a waste discharge permit. The Montana Pollutant Discharge Elimination System Rule requires that any animal confinement facility,

without regard to size, which discharges to state waters must apply for a waste discharge permit. The following is a list of the number of animal units for those types of animal confinement facilities in or expected to be in operation in Montana:

Slaughter and Feeder Cattle	1.0 animal units/animal
Mature Dairy Cattle	1.4 animal units/animal
Swine over 55 pounds	0.4 animal units/animal
Sheep	0.1 animal units/animal
Fish (where discharge occurs on at least 30 days/year)	0.05 animal units/pound

The waste discharge permits issued for animal confinement facilities will generally prohibit any discharge of pollutants unless rainfall in excess of the 10-year/24-hour rainfall or equivalent moisture has been received.

Irrigation return flows will be subject to MPDES permit if there is a point source discharge through a man-made or man-maintained drainage system from 3,000 or more irrigated acres. The parameters to be monitored and the frequency of monitoring will be stated on the discharge permit.

WATER QUALITY STANDARDS

Water pollution control started in Montana in 1907 with passage of legislation designed to protect domestic water supplies. A more comprehensive law was passed in 1955 that dealt with control and protection of water for recreation, agriculture, and industry. The 1955 law also established a water pollution control council and charged it with the tasks of classifying all streams in the state according to their most beneficial uses and establishing water quality criteria for the streams. The 1955 law also involved upgrading the treatment of wastes going into the streams. Montana thus became one of the first states to have enforceable stream classifications.

In 1965, the U. S. Congress passed the Federal Water Quality Act which required that all states classify and

establish water quality criteria for their interstate streams by July 1, 1967. Montana revised its standards for both interstate and intrastate waters and required a higher degree of stream quality than before. Secondary treatment or the equivalent was required of municipal and industrial discharges. In October, 1972, the Federal Water Pollution Control Act Amendments were passed expanding the authority of the Environmental Protection Agency. Uniform water quality standards and enforcement procedures throughout the United States became the objective. Montana revised its water quality standards and adopted these revised standards on July 13, 1973. The new standards became effective in November, 1973.

Montana water quality standards serve as a functional tool in protecting water quality; however, a number of laws, statutes, and regulations complement the water quality standards and significantly assist in protecting water quality.

STATEWIDE MONITORING AND SURVEILLANCE PROGRAM

Prior to 1972, Montana had done little water quality monitoring due to inadequate funding. With increased appropriations provided by the 1971 legislature and the federal government, the state greatly increased its effort. Personnel were added to the staff, and laboratory capabilities were expanded. The present state monitoring program includes compliance monitoring of point sources of wastes including monitoring of municipal and industrial wastes, long-term baseline monitoring of streams, and a statewide program for determining the general quality of all significant surface waters.

The statewide inventory of water quality will identify areas with water quality problems and will provide basic data for water quality management and planning programs. Included in the monitoring is a statewide assessment of the trophic (pollution level) status of Montana's lakes, reservoirs, and ponds. This program is coordinated with the EPA National Eutrophication Survey.

FACILITIES CONSTRUCTION, OPERATION, AND MAINTENANCE

A minimum requirement of primary treatment for all domestic sewage was first adopted by the Montana Board of Health

in 1952. All of Montana's communities have met this requirement, and many of the communities are upgrading their facilities to secondary treatment or are in the process of constructing or planning secondary treatment systems. Since 1956, there has been a federal grant program to assist municipalities in the construction of sewage treatment facilities, including outfall and interceptor sewers. In 1971, the Montana state legislature appropriated $4,000,000 to aid municipalities in construction of these same facilities. The 1973 legislature appropriated $1,600,000 to reimburse municipalities that had proceeded with construction since July 1, 1966, without waiting for state grants. With passage of the Federal Water Pollution Control Act Amendments of 1972, 75 percent of eligible project costs are federally financed. Due to a shortage of federal grant funds, a priority system for allocation must be used. The state, under EPA guidance, establishes priorities for proposed waste treatment projects.

An important part of municipal sewage treatment is proper operation and maintenance of facilities after construction is completed. In an effort to improve operation and maintenance, the state has conducted an operators' school each year. During recent years, this school has had about 100 operators attending. In 1971, a grant was obtained from the federal government for employing two training instructors to establish training programs throughout the state. This activity is in addition to the annual school.

An operators certification program was established in 1968 following enactment of a law requiring certification of those responsible for the operation of sewage treatment or industrial waste treatment systems.

PUBLIC PARTICIPATION

Public participation in the water pollution control is an increasingly important aspect of the state program. Public hearings are held concerning proposed regulations, water quality management plans, and waste discharge permit applications. The state also has an environmental impact statement requirement. These statements are presented to the public for comment, and hearings are conducted on highly controversial issues.

The public also is kept informed by means of a water pollution control advisory council which has been established by law to assist the Water Quality Bureau in preparation of rules and regulations and dissemination

of information to interested groups. Similarly, public meetings are attended on request, and a quarterly newsletter is published by the Water Quality Bureau.

ENFORCEMENT

Montana's laws on water pollution basically state (1) it is unlawful to cause pollution or place materials in a location where they are likely to cause pollution of state waters, and (2) discharge of waste material into state waters without a permit from the Department of Health and Environmental Sciences. Two administrative rules have been adopted by the Board of Health and Environmental Sciences which are the chief elements in Montana's water pollution control program. Montana's water quality standards serve as the primary means for defining pollution, and the Montana Pollutant Discharge Elimination System rule provides the mechanism for authorizing and controlling point source discharges to state waters. Violators of the law, a rule, permit, or order could be subject to injunction, civil penalties up to $10,000 for each day of violation, or criminal penalties with fines not to exceed $25,000 per day of violation and/or imprisonment for not more than one year for an initial conviction and not more than $50,000 per day of violation and/or imprisonment for not more than two years for subsequent violations. Significant steps were taken in 1974 to establish a workable enforcement program, including increasing the legal staff and additional allocation of technical staff.

V. WATER POLLUTION SOURCES

GENERAL

In the Lower Yellowstone Basin water pollution may result from a number of activities, only a few of which are represented by point discharges. Effluents from municipalities are an important source of point discharges. There are 16 potential point sources of this nature in the basin--ten intermittent or continuous discharging municipal sewage treatment facilities, three such facilities now not discharging, one federal installation, and two water treatment plants. In addition, 34 potential industrial point discharges (oil process water discharges) exist within the basin. Characteristics of all known municipal and industrial discharges are presented in Tables 8 and 10. However, most of the water quality problems in the basin are related to non-point sources and primarily siltation due to runoff of erodible soils and irrigation return. Thirty-two agricultural discharges have been identified in the region at the present time. Appendix D contains a table of discharge permits and a schedule of compliance information for dischargers in the Lower Yellowstone Basin.

MUNICIPAL DISCHARGES

Assessments of community water treatment needs are based on the fact that the Lower Yellowstone Basin is an effluent limited segment. Presently, preliminary engineering reports do not exist for communities in this basin. Further assumptions can be summarized as follows:

1. Meeting secondary treatment requirements is considered to be satisfactory for effluent limited drainages.

2. Wastewater treatment facilities should be designed and constructed to insure that secondary treatment requirements will be met. In certain cases, properly designed and operated lagoon systems have been shown to meet effluent limitations. Therefore, to provide a basis for estimating costs associated with obtaining secondary treatment with these systems, only those conforming with the following description are considered to be capable of meeting this level of treatment. The system must contain a minimum of three cells that are adequately designed both on an organic and on a hydraulic basis and amenable to both series and parallel operations with disinfection facilities. It must be realized that such systems may not provide satisfactory treatment in all cases; cost estimates however based on the above assumptions should be realistic. In addition, properly sized and aerated lagoons followed by polishing ponds and disinfection are also considered to be capable of meeting secondary treatment requirements.

3. Organic loading was evaluated on the basis of 100 people per acre per day.

4. Hydraulic loading was evaluated on the basis of 100 gallons per person per day. The lagoon system should be capable of holding 180 days of flow to assure a non-discharge from the lagoon during the winter period.

5. Costs of additional lagoon cells were based on $200 per acre of land and $2 for excavation per cubic yard for less than 75,000 cubic yards and $1 per cubic yard for more than 75,000 cubic yards. This cost should cover appurtenances, engineering, legal costs, etc. Chlorination equipment was estimated to cost $10,000 per facility.

6. When available, previous cost estimates formulated by the Montana Department of Health and Environmental Sciences during the development of an Environmental Protection Agency needs list were used in this report.

Descriptions of the sewage treatment facilities at various communities in the Lower Yellowstone Basin are included in the following discussion. Table 8 is a summary of municipal discharge information. Table 9 shows typical values of selected parameters for the municipal dischargers in the region. All other communities in the basin not noted below use individual septic tanks or seepage pits, which presently are not known to be pollution problems.

BAKER

The sewage disposal system consists of gravity mains discharging into a three-cell lagoon. The lagoon has a surface area of about 30 acres. When the system was originally built, there were only two cells. When the last cell was added, it was connected to the influent line with a splitter box so that it also can be operated in parallel. At the present time the two-cell and single-cell systems are operated in parallel as is the two-cell system. All three cells have a continuous discharge to Sandstone Creek, a small tributary of O'Fallon Creek.

The facility serves an estimated population of 3,000 and was designed for a population equivalent of 3,000. The lagoon seems to be satisfactorily loaded organically. It appears that series operation of the three cells is possible at a minimal cost. The lagoon does not have satisfactory volume to hold winter flow; it is estimated that an additional 83,480 cubic yards will be needed. In addition, a chlorination unit may be needed to provide disinfection for secondary treatment. These improvements which should insure secondary treatment are estimated to cost $95,000.

BELLE CREEK

The sewage disposal system consists of gravity mains discharging into a two-cell lagoon. The total surface area of the lagoon is about

0.75 acres. The system is operated in series. The discharge is continuous and is to Belle Creek, a small intermittent stream, The system was designed for a population equivalent of 100 and serves a population estimated at 120.

The lagoon appears to be slightly overloaded organically and may need an additional 2.0 acres. A capacity for holding winter flow is needed and is estimated at 21,815 cubic yards. In addition, a chlorination unit may be needed to provide disinfection. It would cost about $55,000 to insure secondary treatment.

BROADUS

The sewage disposal system consists of gravity mains emptying into a two-pump lift station located between the cells of a two-cell lagoon. The total surface area of the lagoon is approximately 6.75 acres. The system is operated in parallel. The system serves an estimated 900 people and was designed for a population equivalent of 670. The discharge is intermittent and is to the Powder River. The lagoon seems to be overloaded organically; and this will require an additional 1.25 acres. The capacity for holding winter flow is needed and is estimated at 38,440 cubic yards. The capability for a series operation of three cells and disinfection will be needed to insure secondary treatment. This upgrading of the present system is expected to cost about $88,000.

FAIRVIEW

The sewage disposal system consists of gravity mains, a two-pump lift station, and a single-cell lagoon. The lagoon has a surface area of about 15 acres. Although the city is in Montana, the lagoon is in North Dakota. The lagoon is lowered in the fall of the year in accordance with North Dakota's sewage discharge regulations. The system serves a population estimated at 1,000 and was designed for a population equivalent of 1,250. The discharge is intermittent and is to a drain ditch leading to the Yellowstone River.

The lagoon seems to be satisfactorily loaded organically. The capability of a series operation of at least three cells plus the capacity for holding winter flow is needed. An additional 15,785 cubic yards of storage is estimated to be necessary to hold the winter flow. A chlorination unit will be needed to provide disinfection. These improvements to insure secondary treatment are estimated to cost $43,000.

FALLON

The sewage disposal system consists of gravity mains emptying into a single cell lagoon. This system serves an estimated 100 people. The lagoon does not seem to be overloaded organically. The capability of series operation of at least three cells is needed. An additional 3,157 cubic yards of storage is estimated to be needed to hold winter flow. A facility for disinfection is also needed. These improvements are expected to cost about $17,000.

GLENDIVE

The sewage treatment facilities consist of four small lift stations in the collection system, one main three-pump lift station, and a three-cell lagoon with total surface area of about 66 acres. The first two cells are operated in parallel with this combination in series with the last cell. The system serves an estimated population of 6,300 and was designed for a population equivalent of 6,500. The discharge is continuous and is to Glendive Creek. It is assumed that at a minimal cost, a series operation of the three cells is possible.

The lagoons seem to be satisfactorily loaded organically, but additional capacity is needed to store the winter flow. The needed storage capacity is estimated at 338,786 cubic yards. Disinfection will also be needed. This upgrading of the system to insure secondary treatment is expected to cost about $254,786.

LAMBERT

The sewage disposal system consists of gravity mains, a two-pump lift station, and a two-cell lagoon. The lagoon has a total surface area of about 2.0 acres. The system serves a population estimated at 100. There has been no discharge from this system since construction. The second cell is generally empty and only serves to lower the first cell. No discharge is expected from this system.

MILES CITY

The sewage collection and disposal system consists of gravity mains with two small two-pump lift stations, a master lift station, and a three-cell lagoon. The total surface area of the lagoon is approximately 118 acres. The system was designed for a population equivalent of 12,000 and serves an estimated 10,000 people. The discharge is continuous and is directly to the Yellowstone River.

The lagoons seem to be satisfactorily loaded organically and a series operation of the three cells is possible. Additional capacity for holding winter flow is estimated at 226,958 cubic yards. Disinfection of the effluent will also be needed. These improvements to insure secondary treatment are expected to cost $250,000.

PLEVNA

The sewage disposal system consists of gravity mains discharging into a two-cell lagoon. The lagoon has a total surface area of about 2.1 acres. The system was designed for a population equivalent of 210 and serves an estimated 190 people. The discharge is intermittent and usually occurs only during the fall to lower the lagoon for winter's flow. The discharge is to Sandstone Creek, an intermittent tributary to O'Fallon Creek.

The lagoon seems to be satisfactorily loaded organically. However, the capability of a series operation of at least three cells will be necessary. The capacity for holding winter flow is estimated at 500 cubic yards. If a discharge still results, disinfection of the effluent may be necessary to insure secondary treatment. This upgrading of the system is expected to cost about $12,000.

SAVAGE

The sewage disposal system consists of gravity mains discharging to a single-cell lagoon. The lagoon has a surface area of about 3.0 acres. This system serves an estimated population of 100 and was designed for a population equivalent of 300. The system does not have a discharge at this time.

SIDNEY

The sewage disposal system consists of gravity mains with three small, two-pump lift stations in the collection system; also, one main three-pump lift station is at the lagoon which consists of two cells. The total surface area of the lagoon is approximately 71 acres. The system was designed for a population equivalent of 7,100 and serves a population of 4,550. The system is operated in series but there is no discharge from the second cell; none is expected. The second cell is used only to maintain the operating level of the first cell.

TERRY

The sewage disposal system consists of gravity mains discharging into a two-cell lagoon. The total surface area of the lagoons is approximately 13.25 acres. The system serves an estimated 1,000 persons, and it was designed for a population equivalent of 1,123. The system is being operated in series. The discharge is intermittent and to the Yellowstone River.

The lagoons seem to be satisfactorily loaded organically but the capability for a series operation of three cells will be needed. For holding winter flow, an additional 13,000 cubic yards is estimated to be necessary. Disinfection of the effluent may be needed. These improvements to insure secondary treatment are expected to cost about $37,000.

WEST GLENDIVE

The sewage disposal system consists of gravity mains, a two-pump, dual chamber, lift station, and a two-cell lagoon. The total surface area of the lagoon is about 26 acres. The lagoon is operated in series. The discharge is intermittent and to a back-water area of the Yellowstone River. The system was designed for a population equivalent of 2,600 and serves an estimated 2,000 persons.

The lagoons seem to be satisfactorily loaded organically, but the capability for a series operation of at least three cells is needed. There seems to be sufficient capacity to store winter flow. Disinfection will be needed on the effluent. These improvements which will insure secondary treatment are expected to cost at least $12,000.

MUNICIPAL WATER TREATMENT PLANTS

GLENDIVE

The City of Glendive obtains its raw water from the Yellowstone River. The water treatment plant has a rated capacity of four MGD (million gallons per day). The treatment plant provides sedimentation, coagulation, softening, filtration, stabilization, and sterilization. The plant consists of four low-lift river pumps, an Infilco Accelator, a recarbonator, six rapid sand filters, a clear well of 125,000 gallon capacity, four high service pumps, chemical feed equipment and two 1,000,000 gallon concrete storage reservoirs.

The water discharge from this plant comes from filter backwash and sludge basin flushing. There is no waste treatment and the discharge is directly to the Yellowstone River. Data tabulated below is a typical analysis for this discharge.

Discharge	Date	Flow (MGD)	Total Suspended Solids (mg/l ------ lb/day)		Dissolved Aluminum (mg/l -- lb/day)	
Filter	10/16/74	6.3	1,350	70,900	0.21	10.8
Sludge	10/16/74	0.03	56,500	14,100	0.18	0.04

INDUSTRIAL DISCHARGERS

Industrial waste discharges in the basin are described below and are summarized in Table 10.

HOLLY SUGAR CORPORATION

The waste treatment facility consists of a 380,000 gallon clarifier, a mud pond estimated at 5.1 acres, a four-cell lagoon of total surface area of about 20 acres, and a spray pond. Wastewater originates from three major sources: (1) water used to flume the beets into the plant plus beet wash water; (2) process water used in the extraction of sugar from beets; and (3) condenser water used in the evaporators. Flume and wash water go to a clarifier where mud and associated solid material settle to the bottom and are pumped to the mud pond. Any runover from the mud pond is directed to the lagoons. Decant water in the clarifier is recycled for flume and wash water. In the winter because of snow and ice

Table 8
Summary of Municipal Discharge Information

Municipality	Type of Treatment	Design Pop. Equiv.	Pop. Served	Average[1] Daily Discharge	Type of Discharge	Receiving Water	State Priority List*
West Glendive	2-cell lagoon 26 acres	2,600	2,000	0.05	Interm.	Yellowstone River	4
Terry	2-cell lagoon 13.25 acres	1,123	1,000	0.10	Interm.	Yellowstone River	4
Sidney	2-cell lagoon 71 acres	7,100	4,550	None	N/A	N/A	2
Savage	1-cell lagoon 3 acres	300	100	None	N/A	N/A	4
Plevna	2-cell lagoon 2.1 acres	210	190	0.10	Interm.	Sandstone Creek	4
Miles City	3-cell lagoon 118 acres	12,000	10,000	0.30	Cont.	Yellowstone River	1
Lambert	2-cell lagoon 2.0 acres	200	100	None	N/A	N/A	4
Glendive	3-cell lagoon 66 acres	6,500	6,300	0.25	Cont.	Glendive Creek	1
Fallon	1-cell lagoon 2.0 acres est.	200 est.	100	0.05	Interm.	Yellowstone River	4
Fairview	1 cell lagoon 15.0 acres	1,250	1,000	0.02	Interm.	Yellowstone River	4
Broadus	2-cell lagoon 6.75 acres	670	900	0.05	Interm.	Powder River	3
Belle Creek	2-cell lagoon 0.75 acres	100	120	0.01	Interm.	Belle Creek	4
Baker	3-cell lagoon 30 acres	3,000	3,000	0.20	Cont.	Sandstone Creek	2

[1] Flow in MGD when discharging (million gallons per day).

* 1) Grant project underway
2) Scheduled for Step 1 grant funding in FY 76
3) Too low on priority list to receive funding at this time
4) Not on priority list

Table 9

Summary of Municipal Discharge Data

Name of Municipality	Location (1)	Date	Flow MGD	BOD		TSS		pH	Fecal Coliform	NO_3	PO_4
				mg/l	% Red	mg/l	% Red	S.U.	colonies/100 ml	mg/l	mg/l
West Glendive	16N 55E	8/22/74	0.05	73.0	51.0	164	25.0	9.25	$2.0x10^4$	0.73	2.0
Terry	12N 51E 16B	10/26/73	0.05	15.0	-----	-----	----	8.4	$<10^2$	-----	----
		7/11/74	-----	47.0	72.0	16.0	80.0	9.11	$2.5x10^3$	0.06	5.4
Plevna	08N 58E 31AA	10/17/74	0.15	72.0	86.0	58.0	88.0	8.12	$1.0x10^2$	0.90	9.5
Miles City	08N 47E 23CBB	6/12/74	0.47	75.0	-----	21.0	----	----	-------	4.0	18.0
		9/25/74	0.15	72.0	72.0	108	72.0	9.30	$5.0x10^4$	-----	----
Glendive	16N 56E 18	10/17/73	0.20	74.0	-----	-----	----	7.00	$2.0x10^4$	5.5	31.0
		7/11/74	0.20	87.0	>78	66.0	11	8.00	$9.2x10^3$	3.4	19.0
		8/22/74	0.20	90.0	71.0	66.0	90.0	8.61	$2.0x10^3$	----	----
Fallon	13N 52E 34AD	10/30/74	0.04	86.0	20.0	158	70.0	9.90	$6.0x10^3$	46	0.30
Fairview	24N 60E 17D	8/7/73	0.002	160	0	-----	----	8.90	$7.0x10^3$	10.0	9.8
		10/30/74	0.00	35.0	40	90.0	26	8.83	$3.0x10^3$	17	0.30
Broadus	04S 51E 35BB	10/31/74	TSTM	91.5	45	60.0	74	7.75	$3.5x10^5$	47	0.30
Belle Creek	08S 54E 16C	9/18/73	0.001	78.0	-----	-----	----	8.70	$4.0x10^3$	1.88	21.3
		10/18/74	0.014	52.0	82	36.0	42	9.19	$4.2x10^3$	0.13	34
Baker	07N 59E 11	7/30/73	0.10	105	47	-----	----	----	-------	-----	-----
		10/17/73	0.10	50.0	-----	-----	----	8.70	$3.0x10^3$	-----	-----
		7/10/74	0.10	71.0	58	60.0	44	9.30	$<10^2$	0.4	7.4

(1) See Appendix A

on the beets, there may be a surplus of the reused flume and wash water. This surplus is discharged to the lagoons. Wastewater that comes from the processing of the beets (sugar extraction) also goes to the lagoons. The lagoons are operated in series and discharge to a ditch which empties into the Yellowstone River. Condenser water used in the evaporators goes to the spray pond where it is cooled and reused. Plant supply water is pumped from the Yellowstone River. The plant processes approximately 4,000 tons of beets a day.

MONTANA-DAKOTA UTILITIES STEAM GENERATING PLANT AT SIDNEY

There are several discharges from this operation. First, the steam generating plant has water treatment facilities to provide water for employee consumption. This small water treatment plant necessitates an intermittent filter backwash discharge. During discharge to the Yellowstone River, the flow approximates 0.36 MGD. Secondly, the storm drainage system provides another intermittent discharge of approximately 0.02 MGD to the Yellowstone River.

In addition, thermal discharges occur from condenser and boiler blowdown water. There are two different discharge structures for the condenser water discharge. One is used during those months when the river is normally ice free. To utilize the heat of the discharge water, the other structure is used during the winter months in order to keep the river ice free around hte water intake pumps. Condenser and boiler blowdown discharges together account for about 30.3 MGD. Condenser water discharge is continuous but the boiler blowdown is intermittent.

Finally, a discharge to the Yellowstone River also occurs from the ash ponds. It is continuous and is estimated at 0.76 MGD. The state discharge permit covers only the cooling water discharge and the ash pond overflow.

MONTANA-DAKOTA UTILITIES STEAM GENERATING PLANT AT GLENDIVE

This steam generating plant only is used a couple of times each year and then just for a few days. The Production and Transportation Division uses a small office building next to the generating plant. The building uses well water for the air conditioning system. After passing through the heat exchanger in the air conditioning system, the water is discharged to the Yellowstone River. During that period of the year when the air conditioning system is not used, the well water is directly discharged to the Yellowstone River at a rate of about 2,000 GPD.

There are three discharges associated with the generating plant itself. These flow to the Yellowstone River. The roof and floor drains discharge about 150 GPD of wash and storm water. There is a screen washing facility on the water intake structure. This discharges about 822 GPD which washes sediment back to the river. Both boiler blowdown and cooling water discharges occur through the same structure. This discharge is estimated at 0.453 MGD and is the only discharge now under State permit.

SIDNEY RENDERING COMPANY

The treatment facilities for this rendering plant consist of a lagoon. A discharge has not yet occurred from this facility; none is expected at the present time.

MILES CITY PACKING COMPANY

The treatment system for slaughtering wastes at the Miles City Packing Company consists of a two-cell lagoon with a combined surface area of about 0.35 acres. There is no current discharge from this system; none is expected.

MILES CITY SAND AND GRAVEL

The treatment system for this gravel washing operation consists of a 0.33 acre settling pond. The discharge from this pond is intermittent to the Yellowstone River. This system seems to provide adequate treatment.

RAHR MEAT COMPANY AT GLENDIVE

The treatment facilities for the slaughtering wastes at the Rahr Meat Company consist of septic tanks used as primary settling basins, skimming tanks, a single-cell aerobic lagoon of about 11,590 gallon capacity, and a second single-cell lagoon of about 0.23 acres. The system is operated in series, and since the construction of the second lagoon, no discharge has occurred.

GARY OPERATING COMPANY - BELLE CREEK

Wastewater discharges from this oil and gas field originate from production water. Water is first separated from the oil and gas at a treater; from there the water is discharged to ponds where residual oil is skimmed from the surface. No other treatment is provided and effluent from these ponds taken from below the surface level.

In the Gary Operating Company oil field, there are 24 discharges. 20 of these discharges are under permits through the NPDES permit program. The remaining four are being processed through the State MPDES permit program. All of the discharges are ultimately to the Little Powder River either through Belle, Wright, or Ranch Creeks, or through the East Fork of the Little Powder River.

SHELL OIL COMPANY - CABIN CREEK

Wastewater discharge from the Cabin Creek field is production water from oil and gas wells. The water is separated from the oil and gas at a treater. This water is then discharged to a skimming pond where any residual oil is removed. Discharge from this pond is taken from below the water surface. There is one discharge in this field that is liable

Table 10

Summary of Industrial Waste Information

Name of Industry	Type of Treatment	Type of Discharge	Receiving Water	Average Daily Discharge
Holly Sugar Company Sidney	380,000 gallon clarifier; 5.1 acre mud pond; 4-cell lagoon (about 20 acres); condenser water spray pond	Continuous	Yellowstone River	0.95 MGD
MDU Generating Plant, Sidney	Ash ponds	Continuous	Yellowstone River	0.76 MGD
MDU Generating Plant, Glendive	None	Intermittent	Yellowstone River	0.45 MGD
Sidney Rendering Company	Lagoon	None	N/A	N/A
Miles City Packing Company	2-cell lagoon (about 0.35 acres)	None	N/A	N/A
Miles City Sand & Gravel Company	Settling Pond (about 0.33 acres)	Intermittent	Yellowstone River	-------
Rahr Meat Company Glendive	Settling & skimming tanks; single-cell lagoon (about 11,590 gallons); single cell lagoon (about 0.23 acres)	None	N/A	N/A

Table 10
(continued)

Name of Industry	Type of Treatment	Type of Discharge	Receiving Water	Average Daily Discharge
Gary Operating Co., Belle Creek	Skimming and settling ponds	Continuous	Little Powder River	1.7 MGD
Shell Oil Company, Cabin Creek	Skimming and settling pond	Continuous	Cabin Creek	0.05 MGD
Union Texas Petroleum Company, Belle Creek	Skimming and settling pond	Continuous	Belle Creek	0.05 MGD
Union Texas Petroleum Company, Glendive	None	Intermittent	Cabin Creek	0.03 MGD

to be under the State MPDES permit program. This discharge is to a normally dry gully tributary to the Middle Fork of Cabin Creek.

UNION TEXAS PETROLEUM COMPANY - BELLE CREEK

Wastewater discharge is production water from oil and gas wells. The water is separated from the oil and gas at a treater. From the treater, the water is discharged to a skimming pond where any remaining oil is allowed to surface. This discharge from the skimming pond is from below the surface with no additional treatment provided. There is one discharge to Belle Creek that is liable to be under the State MPDES permit program.

UNION TEXAS PETROLEUM COMPANY LIGHT ENDS REFINERY NEAR BAKER

In the process of transferring oil and gas from wells to the Light Ends Refinery, a brine is used. Normally, water separated from the oil and gas at the refinery is used in making additional brine; the water is pumped to a pond where the brine is prepared. In the case the pump breaks down, there is a discharge outlet in the pump house. This discharge is to a normally dry gully that is a tributary to Cabin Creek. It is questionable whether this occasional discharge ever reaches Cabin Creek except during periods of runoff. This discharge, however, is liable to be under an MPDES permit.

AGRICULTURAL WASTE DISCHARGES

Extensive information regarding agricultural waste discharges is not readily available but a variety of such discharges are known to be present within the basin. Such discharges include irrigation return flows, animal confinement facilities, and runoff from range and cultivated land. The information contained in this report has been compiled from data collected in conjunction with the Montana Pollutant Discharge Elimination System and from limited field observations. Animal confinement facilities that have applied for or received MPDES permits are summarized in Table 11.

Irrigation return flows are subject to MPDES permit requirements if there is a point source discharge through a man-made or man-maintained drainage system from 3,000 or more irrigated acres. Applications applied for in accordance with the MPDES Rule are summarized in Table 12. Parameters to be monitored in conjunction with the irrigation return flow permits and the frequency of monitoring will be stated on the waste discharge permit.

NON-POINT SOURCES

Little consideration has been given to non-point sources in the past because of the difficulty in their identification. Pollutants contributed by these sources within the basin may be significant. Although any one specific area of non-point waste may have a minor effect, several such sources on a stream may produce water quality problems. Non-point pollution arises from a variety of activities, including

Table 11

SUMMARY OF CONFINED FEEDING OPERATIONS IN THE
LOWER YELLOWSTONE BASIN HAVING APPLIED FOR
A WASTE DISCHARGE PERMIT Or received

OPERATION	LOCATION TNS RNG SEC TRACT	CAPACITY IN ANIMAL UNITS	LOT SIZE (ACRES)	10 YR-24 HR RAINFALL (IN.)	WASTE TREATMENT FACILITY	RECEIVING WATER
Valley Vu Feedlot, Fairview	25N 60E 25 BC	4500	40	2.6	1500 acres-solid waste; 3 retention ponds, 13 acre ft. capacity	Missouri River
Reuben Schroeder, Terry	11N 50E 20 B	2500	15	2.4	175 acres-solid and wet waste	Yellowstone River
Yellowstone Livestock Company, Sidney	23N 59E 33 DD	5700	5	2.6	solid waste, stock piles for distribution to farmers; retention pond; 1.1 acre feet capacity	Yellowstone River
Tenderloin Industry Inc., Sidney	22N 59E 03 CC	5600	50	2.6	2 retention ponds, 11 acre-ft. capacity; solid waste stock piled for distribution to farmers	Lonetree Creek
C. E. Cattle Company, Miles City	08N 48E 05 DD 04 CC 08 AA	4000	120	2.3	1200 acres-solid waste retention pond, 23 acre-ft. capacity	Yellowstone River
Lucky Charm Dairy, Glendive	14N 54E 13 CC	210	1.0	2.2	200 acres-solid waste manure pit; 10-day storage anerobic lagoon-180 day storage 1/2 acre evaporation pond	Yellowstone River

Table 12

Summary of Irrigation Systems in the Lower Yellowstone Basin having applied for a Waste Discharge Permit.

Irrigation System	Number of Irrigated Acres	Est. Average Return Flow (MGD)
Lower Yellowstone Irrigation District No. 1	34,500	89
Lower Yellowstone Irrigation District No. 2	17,500	54
Savage Irrigation District	2,215	1.8
Intake Irrigation District	822	1.3

agriculture, runoff from urban areas, construction projects, inadvertent spills, and natural phenomena.

Irrigation return flows from numerous small areas can exhibit this cumulative effect on state waters. These flows are higher in total dissolved solids and sediment and contain more nutrients and pesticides than water applied to the field.

Runoff from pasture lands may carry animal wastes and sedimentation to state waters. A number of pastures in the basin use streams as a boundary. In many cases in these pastures there is no vegetation on the stream bank or in the immediate floodplain due to livestock concentrating in these areas. As a result, there is no protection from erosion due to irrigation, storm runoff, and high water. The use of lands in the basin that exhibit sparse vegetation due to fragile soils for pastures tends to amplify stream sediment in these areas.

Runoff from agricultural land where saline seep has developed presents another potential non-point source problem. In contrast to the Middle Yellowstone Basin where few saline seep areas have been specifically identified at the present time (Ref. 2), a number of such areas have been diagnosed in the eight main counties of the Lower Yellowstone Basin. Table 13 summarizes available estimates of acreage affected by saline seep in each of these counties (Ref. 1). Undoubtedly, these acreage figures will continue to increase as added regions become identified as having saline seep problems and as new problem areas develop from poor water and land management practices. The marked increase in recognized saline seep acres from 1969 to 1973 (Table 13) is illustrative of this potential.

TABLE 13. IDENTIFIED SALINE SEEP ACREAGE IN THE EIGHT MAIN COUNTIES OF THE LOWER YELLOWSTONE BASIN IN 1969 AND 1973*

County	July, 1969	May, 1973
Carter	---	---
Custer	---	250
Dawson	---	2,000
Fallon	---	5,000
Powder River	---	---
Prairie	---	100
Richland	1,500	3,000
Wibaux	---	1,000
Total	1,500	11,350

*Estimates made by the Soil Conservation Service and agricultural research personnel; tabulated by Clair O. Clark, soil scientist (Ref. 1)

Runoff from cultivated lands may present potential non-point pollution problems from fertilizers, pesticides, dissolved salts, and sediment. Increased demand for food causes an increased demand for farm products and this in turn leads to the use of more fertilzers and pesticides to increase the yield on agricultural lands. Removal of brush and trees from stream banks and the floodplain to increase stream access, control weeds, and increase the amount of cropland causes increased erosion.

Community storm drain systems present another non-point pollution source due to a variety of hazardous materials including: oil and grease, coliforms, biologically oxidizable material, suspended solids, plus various toxic metals. The EPA has to date excluded storm drainage from the NPDES program and they have been excluded from the MPDES permit program. The impact of these discharges on water quality in the Lower Yellowstone Basin is probably significant.

Construction projects and stream bank riprapping are important non-point pollution problems. Increases in coal and energy related development in the basin will increase this type pollution. Increases in population project to occur in the basin will increase the number of inadvertent spills of toxic or deleterious materials into surface or groundwater systems.

There are several suspected areas within the Lower Yellowstone Basin where soils and geological formations are fragile and erosion and sedimentation cause natural water quality problems. There are also suspected geological formations from which toxic or deleterious materials are dissolved and enter the hydrologic cycle.

In view of the lack of existing information on non-point sources, any rating of relative priorities of these sources can only be developed as to suspected impact on receiving waters and to future potential. With this constraint the following is the non-point priority list for the basin:

1. agricultural non-point discharges;

2. runoff from saline seep areas;

3. storm drains and urban runoff;

4. construction projects (subdivisions, roads, bridges, riprapping, etc.);

5. accidental discharges (spills).

VI. SURFACE WATER RESOURCES

General Features

The Lower Yellowstone River Basin contains five sub-basins. The major streams in these sub-basins are:

1. The Yellowstone River mainstem from the confluence of the Tongue River to the confluence of the Powder River;
2. The Little Powder River;
3. The Powder River;
4. O'Fallon Creek, and;
5. The Yellowstone River mainstem from the confluence of the Powder River to the Montana-North Dakota state boundary.

The U. S. Geological Survey (USGS) has maintained several stream flow gaging stations in or adjacent to the basin. At the present time seven of these stations are active. Streams in the Lower Yellowstone Basin have considerable variations in daily, monthly, and annual discharge.

An examination of the stream flow data available for the Yellowstone River at Miles CIty and Sidney shows that spring runoff originating from within the Lower Yellowstone Basin itself occurs in the Yellowstone River during this period. For various small tributary streams of the Yellowstone, Powder, and Little Powder Rivers a major portion of the annual flow occurs at this time. For the major streams, rivers, peak flows generally occur from mid-June to mid-July due to snowmelt from mountain snow packs.

The Powder River is regulated to some extent by three reservoirs in Wyoming; the flow of the Yellowstone is regulated to some extent by the Bighorn River Reservoir (Yellowtail Dam) and is substantially influenced by diversions for irrigation. Peak flows for the remaining streams in the Lower Yellowstone Basin may occur in mid-winter due to chinook warming trends or in late spring and summer due to heavy rain storms. This is characteristic of a prairie area with a semi-arid climate. The sparse vegetation in a majority of the basin and soils of low infiltration rates produce conditions favorable for rapid runoff and rapid changes in flow.

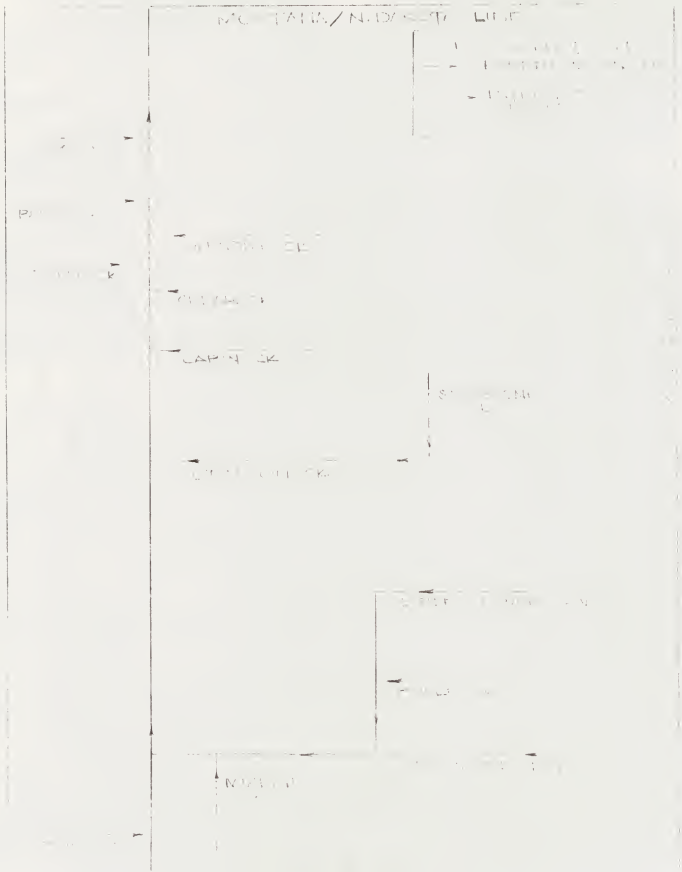
Table 14summarizes stream flow information and data for various streams in the Lower Yellowstone River for which continuous discharge data is available. Figure 2 is a schematic diagram of surface waters in the Lower Yellowstone River Basin. Figures 3 and 4 are graphs of average monthly mean discharge in cubic feet per second for the gaging stations within or adjacent to the basin for which such data is available. The data for the stations on the Yellowstone is that available subsequent to regulations by Yellowtail Dam on the Bighorn River (as of November, 1965).

Table 14

Summary of Sub-basin Size and Stream Flow From
Gaged Streams in the Lower Yellowstone River Basin

STATION	LOCATION	DRAINAGE AREA IN BASIN (Sq. Miles)	YEARS OF RECORD	MIN. STRM. FLOW (cfs)	AVERAGE ANNUAL FLOW (cfs)
Yellowstone River at Miles City	08N 47E 28BC	0.0	9/22 - 9/23 8/28 - present	2,290	13,550
Powder River at Moorhead	09S 48E 08B	72	5/29 - 9/72	0.0	453
Little Powder River nr Broadus	05S 52E 21BA	650	5/47 - 9/53 3/57 - 9/72	0.0	39.6
Powder River nr Locate	08N 51E 14BC	3,204	3/38 - present	0.0	620
Burns Creek nr Savage	19N 57E 26	233	10/57 - 9/67	0.0	5.9
Yellowstone River nr Sidney	22N 59E 09CAC	11,649	10/10 - 9/31 10/33 - present	2,360	14,160

FIGURE 2 . SCHEMATIC DIAGRAM OF SURFACE WATERS IN THE LOWER YELLOWSTONE RIVER BASIN.



Yellowstone River Sub-Basin - Tongue River to Powder River

This sub-basin contains approximately 1,506 square miles. This reach of the Yellowstone River flows generally in a northeasterly direction (Plate I, Figure 1). Tributary streams in this area are intermittent or ephemeral and have relatively small drainage areas with the exception of Sunday Creek. Sunday Creek has a relatively large drainage area, but does not have a sustaining groundwater flow. Sunday Creek probably has flow characteristics of a stream with a prairie type of drainage with its high flows between late February and early May. In September 1974, the USGS established a continuous recording flow gaging station on Sunday Creek near its mouth near Miles City. This stream originates in the rolling foothills north of Miles City. Sunday Creek gets some irrigation return water mostly from flood irrigation off small reservoirs in its drainage. The flow of Sunday Creek is insignificant in comparison to the flow of the Yellowstone.

There are several diversion ditches and numerous pumps for irrigation along the Yellowstone River in this reach. Waste irrigation return waters from these diversions empty into the Yellowstone from various drains in this sub-basin. There is an active USGS gaging station on the Yellowstone River at Miles City below its confluence with the Tongue River. Figure 4 shows a graph of average monthly mean discharge in cubic feet per second for the Yellowstone River at Miles City for a six-year period (1967-1972 water years) (Ref. 1). As was pointed out in the Water Quality Management Plan entitled, "Middle Yellowstone River Basin," the Bighorn River has been supplying about one-half the flow to the Yellowstone during the months of October, November, December, January, February, March, and April (Ref. 2). The Tongue River Reservoir does not have the regulatory capacity of Yellowtail Reservoir and, therefore, the Tongue River does not significantly alter the flow of the Yellowstone River below their confluence.

Little Powder River Sub-Basin

The Little Powder River originates in Wyoming on the eastern slopes of the Bighorn Mountains. The river flows generally northward to its confluence with the Powder River near Broadus. The drainage area in Montana is approximately 650 square miles and has a prairie runoff characteristic. There are a few small diversions along the Little Powder River for irrigating small hayfields. High flows occur in March which is characteristic of the prairie drainage. The flow increase in May is probably due to the upper drainage in Wyoming (see Figure 3). All tributary streams to the Little Powder River in Montana are intermittent as is the Little Powder River since it has periods of zero flow. The tributary streams have relatively small drainages and generally only flow during the late winter snow runoff and in response to rainfall. The only continuous recording flow gaging station in Montana is maintained by the USGS on the Little Powder River near its confluence with the Powder River. The graph of the Little Powder River in Figure 3 was prepared from data collected at this station (Ref. 1). The USGS maintains a flow gaging station in Wyoming on the Little Powder River about six miles upstream from the Montana-Wyoming border. This station was established in water year 1973.

Powder River Sub-Basin

This sub-basin contains approximately 3,273 square miles of drainage in Montana. The Powder River originates in the Bighorn Mountains of Wyoming.

It flows generally northward into Montana joining the Yellowstone River near Terry. The USGS maintains two flow gaging stations on the Powder River in the sub-basin. One is at Moorhead near the Montana/Wyoming border and the other is at Locate about 25 miles above the Powder River's confluence with the Yellowstone River. The graphs for the Powder River (Figure 3) was prepared from data collected at these stations (REf. 1).

The Powder River is regulated by three storage reservoirs in Wyoming and several irrigation diversions. There are two tributary streams to the Powder River which have relatively large drainage areas, the Little Powder River and Mizpah Creek. All other tributary streams have small drainage areas and only flow during the late winter snow runoff and in response to rainfall. Mizpah Creek originates in the rolling foothills just northwest of Broadus and flows gnerally northward emptying into the Powder River about ten miles above Locate. Mizpah Creek is an intermittent stream and probably has flow characteristics typical of streams with only prairie drainages. Although there may be distinct reaches of Mizpah Creek which are continuously flowing, the stream does not have a sustaining base groundwater flow. The USGS has recently established a continuous recording flow gaging station on Mizpah Creek near its mouth.

Comparing the graphs in Figure 3, Powder River at Ashland, Little Powder River near Broadus, and Powder River at Locate, it seems that the significantly high flows for March on the Powder at Locate are not simply the sum of the flows on the Powder at Ashland and the Little Powder River near Broadus. A considerable amount of surface water must be coming into the Powder River from Mizpah Creek and the other tributaries.

O'Fallon Creek Sub-Basin

O'Fallon Creek originates in the rolling foothills southwest of Baker. The drainage area for this sub-basin is approximately 1,553 square miles. O'Fallon Creek flows generally northward meeting the Yellowstone River near the Town of Fallon. Sandstone Creek is the only major tributary of O'Fallon Creek. Sandstone Creek orignates in the Baker area. There is a small flood control dam on Sandstone Creek in Baker which forms Baker Lake. Since the dam was built in 1908, sedimentation has reduced the capacity of the lake by about 1/3 and thus has reduced its flood control ability. There is no continuous recorded flow data available for this sub-basin. Intake Water Company has employed a consulting firm to gather information and data on various streams in eastern Montana. As part of this contract, the firm has established a continuous recording flow gaging station on O'Fallon Creek near Ismay and this data is being made available to the Montana Department of Health and Environmental Sciences, Water Quality Bureau (Ref.3). It is expected that flow characteristics will be typical of streams with a prairie drainage. Both O'Fallon and Sandstone Creeks are intermittent. Any significant contribution to the flow of the Yellowstone River from O'Fallon Creek would be expected to occur between late February and early April.

Yellowstone River - Powder River to the Montana/North Dakota border

In this 4,667 square mile sub-basin of the Yellowstone, the river flows mostly northeastward crossing the Montana/North Dakota border about ten miles above its confluence with the Missouri River. The two major tributaries

to the Yellowstone River in this segment are the Powder River and O'Fallon Creek. There are several minor creeks in this sub-basin for which some flow data is available: Fox, Cabin, Cedar, Glendive, Sevenmile, and Burns Creeks. The flow data for Fox, Cabin, Cedar, Glendive, and Sevenmile Creeks was obtained when samples were collected by the Water Quality Bureau.

The data for Burns Creek is from a continuous recording station the USGS had maintained on the stream (Ref.1,4, 5). Burns Creek, which originates west of Savage, is a stream with a relatively small drainage area; it flows into the Yellowstone from the northwest. Figure 4 shows a graph of the average mean monthly discharge of Burns Creek for the 10-year period, water year 1958 to water year 1967. As this graph shows, substantial flow occurs from February to July with March being the month with highest flow. This is the flow pattern that is expected from a stream with only prairie drainage in an area of semi-arid climate.

Glendive, Cedar, and Cabin Creeks also are intermittent streams with flow characteristics expected to be like that of Burns Creek. They have somewhat larger drainage areas than Burns Creek. Glendive, Cabin, and Cedar Creeks all originate in the rolling hills between Glendive and Baker (Plate I, Figure 1).

Sevenmile and Fox Creeks seem to flow year round due to a base groundwater flow. This base groundwater flow is small and is an insignificant contribution to the Yellowstone River. Sevenmile Creek originates west of Glendive and has a drainage area comparable to that of Burns Creek. Fox Creek originates west of Sidney and also has a drainage area comparable to Burns Creek.

The USGS maintains a flow gaging station on the Yellowstone at Sidney. A graph of the average mean monthly discharge of the Yellowstone River at Sidney for the six-year period since regulation by Yellowtail, water year 1967 to water year 1972 (Ref. 1) is shown in Figure 4 . Of particular interest is the peak in March. Comparing the graphs for the Yellowstone River at Miles City and Sidney's (Figure 4), the Yellowstone River at Miles City has a lower average mean monthly discharge, but this difference is about 4,500 cfs. The Powder River, Figure 3 , shows about 2,000 cfs for the average mean monthly discharge for March. This leaves a significant contribution from within this sub-basin.

There is substantial diversion for irrigation along the Yellowstone River in this reach, the largest being the Lower Yellowstone Diversion Dam at Intake.

FIGURE 3 . AVERAGE MONTHLY DISCHARGE - POWDER AND LITTLE POWDER RIVERS (REF. 1)

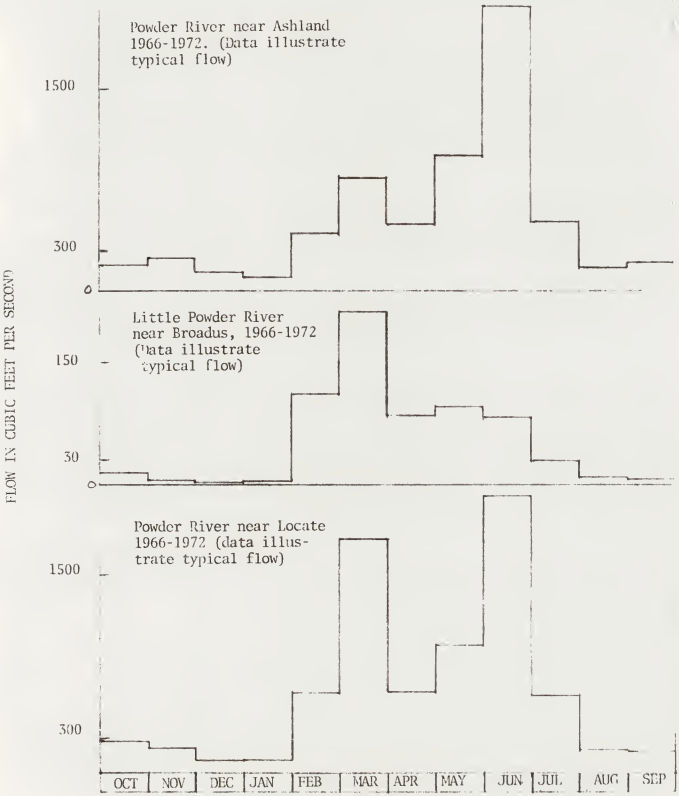
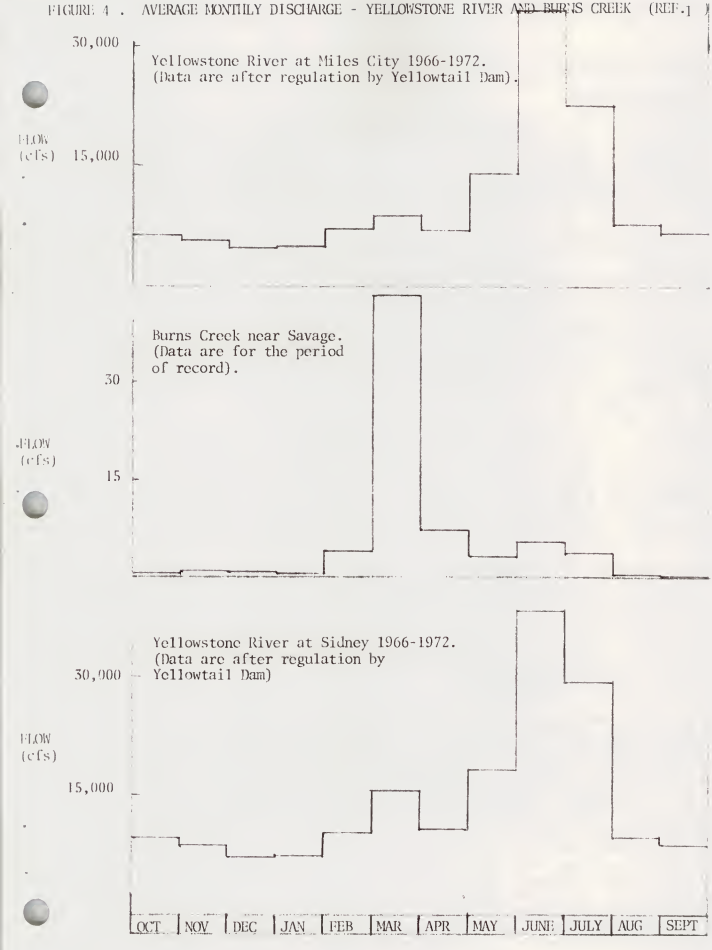


FIGURE 4 . AVERAGE MONTHLY DISCHARGE - YELLOWSTONE RIVER AND BURNS CREEK (REF.1)



VII. SURFACE WATER QUALITY

GENERAL FEATURES

Little water quality information is available for streams in the Lower Yellowstone Basin. Some water quality data has been collected by the USGS for the Yellowstone, Powder and Little Powder Rivers. Table 15 presents a summary of the type of water quality and flow data available from the USGS. The Montana Water Quality Bureau sampling sites in the basin are listed in Table 16 .

Concentrations of total suspended sediment (TSS) increase rapidly in streams with increases in flow. This is caused in part by runoff from erodable soils and also by erosion of stream channels. Increases in stream flow results not only in enlarged stream cross sections, but also in higher water velocity whch enables the stream to more efficiently scour its banks and bottom. During the rising phase of flow, more loosely deposited and held sediments are readily resuspended and moved; as a result, most of this material is unavailable by the time the flows recede. Information from the Yellowstone River near Sidney in 1972 (Ref. 1) was selected to serve as an example of this flow-related variation in TSS in the Lower Yellowstone Basin. This data is summarized below:

Date	Flow Range (cfs)	Median	TSS Range (mg/l)	Median
5/13-18	13700-16900	15350	335 - 745	570
6/4-9	39300-51400	48350	1630 - 2680	2030
6/10-14	54300-59300	57700	2160 - 3410	2500
6/15-20	40200-53600	42700	1000 - 1680	1205
9/21-26	9160-9940	9460	142 - 222	159

In contrast to TSS, concentrations of dissolved constituents in streams typically are inversely related to flow. This is caused by dilution from snowmelt or rainstorms. However, this relationship is not directly proportional; that is, the decline in dissolved solid concentrations is not as great as the increase in flow. For example, an increase in stream flow by a factor of ten may result in only a 50% decrease in concentration of dissolved constituents. As a result, the net effect of increased flow is an increase in total loads of dissolved materials.

Since concentrations of dissolved and suspended materials in a stream are dependent upon flow, simple averages of chemical concentrations from several samples may be quite misleading. For example, suppose four samples were collected during the period of a year: an August, warm weather, low flow sample; November and February samples collected at two brief periods of mid-winter snowmelt and runoff; and a June sample collected during the distinct spring runoff period. The November and February samples would not be typical of true stream conditions. Mid-winter snowmelts during warming periods with the corresponding increases in stream flow are quite common in the Lower Yellowstone Basin. A simple mean of the four concentrations for any particular parameter would not at all represent a true yearly average for the constituent since three out of the four samples would have been collected at relatively high flow conditions. The net effect would be an under-estimation of the actual annual mean. STORET statistical

Table 15.

SUMMARY OF THE MAJOR UNITED STATES GEOLOGICAL SURVEY WATER QUALITY (WQ) AND CONTINUOUS DISCHARGE MONITORING STATIONS IN OR NEAR THE LOWER YELLOWSTONE BASIN (SED-SEDIMENT, DIS-DISCONTINUED).

STREAM AND SITE	LOCATION (1) TNS RNG SEC	DATA TYPE FLOW	WQ	SED	PERIODS OF COLLECTION (MONTH AND YEAR)
Yellowstone River					
near Miles City	08N 47E 31CD		X		10/68-current
near Miles City	08N 47E 28BC	X			9/22-9/23; 8/28-current
near Sidney	22N 59E 09AC	X			10/10-9/31; 10/33-current
near Sidney	22N 59E 09AC		X(2)		9/48-current
near Sidney	22N 59E 09AC			X	10/71-current
Sunday Creek					
near Miles City	08N 47E 03CC	X			10/74-current
Little Powder River					
near state line	58N 71W 36BA (Campbell County, WY)		X		5/69-5/70 (Dis)
near Broadus	05S 52E 21AB	X			3/38-9/72 (Dis) (3)
Mizpah Creek					
at Mizpah	06N 51E 24CA	X			10/74-current
Powder River					
at Moorhead	09S 48E 08B	X			5/29-9/72; 10/74-current
at Moorhead	09S 48E 08B		X(2)		2/51-9/53; 10/55-9/57; 7/69-7/72; 10/74-current
at Moorhead	09S 48E 08B			X	10/74-current
near Locate	08N 51E 14CB	X			3/38-current
near Locate	08N 51E 14CB		X		12/49-7/63; 10/74-current
near Locate	08N 51E 14CB			X	3/50-9/53; 10/74-current
Burns Creek					
near Savage	19N 57E 26	X			10/57-9/67 (Dis)

(1) See Appendix A. (2) Some bacteriological data available for these sites.
(3) Station recently established at an upstream site in Wyoming.

Table 16

SUMMARY OF STREAM SAMPLING SITES IN THE LOWER YELLOWSTONE BASIN COLLECTED BY THE WATER QUALITY BUREAU (STATE DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES) IN 1973 AND 1974.

STREAM	SITE	MAJOR LOCATION (1) TNS RNG SEC	SUB-BASIN (REF.)	NO. OF SAMPLES
Yellowstone River	at Miles City	08N 47E 28BC	42K	9
Sunday Creek	near Miles City	08N 47E 03CC	42K	3
Little Powder River	near Broadus	05S 52E 28AA	42I	5
Sand Creek	near Volborg	02N 51E 08BB	42J	1
Mizpah Creek	at Olive	03S 50E 26CC	42J	1
Mizpah Creek	near Volborg	02N 51E 09CD	42J	2
Mizpah Creek	at Mizpah	06N 51E 24CA	42J	4
Sheep Creek	near Mizpah	06N 52E 06CC	42J	1
Powder River	near Moorhead	08S 48E 28CB	42J	2
Powder River	at Broadus	05S 51E 03DA	42J	5
Powder River	near Powderville	01S 54E 17CA	42J	2
Powder River	at Locate	08N 51E 23DC	42J	3
Powder River	near Terry	11N 50E 03DC	42J	4
Sandstone Creek	near Plevna	08N 57E 35BB	42L	3
Pennel Creek	near Ismay	09N 56E 04DA	42L	1
O'Fallon Creek	near Ismay (2)	08N 56E 30DA	42L	4
O'Fallon Creek	at Fallon	12N 52E 02BA	42L	5
Cabin Creek	near Fallon	13N 54E 03AC	42M	3
Cedar Creek	near Glendive	14N 55E 34BD	42M	2
Sevenmile Creek	at Glendive	15N 55E 03BD	42M	1
Hay Creek	near Lindsay	25N 58E 26DD	42M	1
Glendive Creek	near Glendive	16N 56E 19DD	42M	3
Fox Creek	near Sidney	22N 58E 25AA	42M	3
Lonetree Creek	at Sidney	25N 57E 36BC	42M	1
Yellowstone River	at Terry	12N 51E 10CD	42M	1
Yellowstone River	near Fallon	13N 52E 27AC	42M	2
Yellowstone River	near Glendive	17N 56E 07AC	42M	2
Yellowstone River	near Sidney	23N 60E ----	42M	1

(1) See Appendix A.
(2) Flow at this site is being collected by Hurlbut, Kersich and McCullough of Billings; station initiated May 8, 1974.

summaries suffer in this manner since concentrations are not flow weighted. Standard deviations as large or larger than the calculated mean value of a statistical distribution are indicative of non-uniform distributions of data; such large variances are common in STORET data. If concentrations are used rather than loads to describe water quality, the maximum-minimum values for a parameter from a series of samples would probably be the most valuable statistic. Statistically, water quality data should be flow related with the simplest system being categorized by low and high flow. Another data preservation technique is to list the basic data obtained from samples collected. This approach is used in this particular report.

Mean concentrations of common ions and specific conductances for high and low flow conditions at major sites on the Powder, Tongue and Yellowstone Rivers in eastern Montana is shown in Table 17 . The confluences of the Powder and Tongue Rivers occur between the two Yellowstone water quality sites. This data illustrates the wide variations in quality due to changes in flow. Concentration of dissolved ions increases with decreasing flows by a factor of 1.4 to 3.7. Similarly, specific conductance increases downstream in the Yellowstone River -- at high flows by a factor of 1.28 in contrast to an increase of 1.12 in times of low flow. With a few exceptions, major tributary streams to the Yellowstone River in eastern Montana have distinctly higher concentrations of common ions and higher specific conductances than the receiving streams.

There are five sub-basins within the Lower Yellowstone Basin (Ref. 2):

(1) Yellowstone River between the Tongue and Powder Rivers;

(2) Little Powder River;

(3) Powder River;

(4) O'Fallon Creek;

(5) Yellowstone River from Powder River to the Montana-North Dakota state line.

The quality of surface water in each sub-basin will be considered individually in this report. Water quality data was obtained primarily from two sources -- from the USGS (Ref. 1, 3-6) with supplemental collections by the State Water Quality Bureau of the Montana Department of Health and Environmental Sciences. All data dated prior to 1973 was collected by the USGS. All data dated 1973 and 1974 were collected by the Water Quality Bureau. To illustrate flow-related variations in water quality data were selected for high flows, low flows, and warm-weather low flows. Data for water years (1966 to 1972) was primarily used in this report.

Available data obtained by the Water Quality Bureau for 28 stream sites have been tabulated and listed by sampling site and date.

Descriptions of field procedures and method of analyses are in accordance with standard techniques (Ref. 7-12). Trace metals data obtained by the

Table 17

Mean high flow and low flow values of common water quality parameters for several water quality sites in the eastern portion of the Yellowstone Basin (compiled from United States Geological Survey Water Quality Records, 1969-1972, Ref. 1). Values for the dissolved ions are in mg/l.

Stream and Site	Typical Flows		Calcium		Magnesium		Sodium		Bicarbonate		Sulfate		Chloride		Specific Conductance	
	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Yellowstone River near Miles City	34000	5500	30	64	9	23	24	65	112	201	70	216	4.4	11.0	360	732
Tongue River near Miles City	1500	200	41	73	24	49	32	73	181	315	120	268	3.2	4.4	569	959
Powder River at Moorhead	1200	150	93	169	29	74	62	225	---	---	450	853	47	152	1167	2233
Yellowstone River near Sidney	3400	6000	38	64	12	26	37	73	138	219	110	218	7.8	11.8	459	817

Water Quality Bureau are termed "total recoverable" metals that were determined from unfiltered samples that were acidified with 5 ml. of concentrated nitric acid (Ref. 7). Common constituents and metals are designated by their chemical symbols with concentrations given in milligrams per liter (mg/l). The following abbreviations and concentration units also are used:

Flow ..... cubic feet per second (cfs)
(an "E" denoted an estimated flow)
Temp ..... temperature (degrees centrigrade)
DO ..... dissolved oxygen (mg/l)
BOD ..... five-day, bio-chemical oxygen demand (mg/l)
FC ..... fecal coliforms (counts per 100 ml of sample)
Turb ..... turbidity (JTU--Jackson Turbidity Units)
TSS ..... total suspended sediment (mg/l)
SC ..... specific conductance (micromhos per cm at 25°C)
TA ..... total alkalinity (mg/l $CaCO_3$)
TH ..... total hardness (mg/l $CaCO_3$)
DS ..... calculated dissolved solids (mg/l) (sum of constituents)
SAR ..... sodium adsorption ratio (Ref. 13, pp. 228-229)

Yellowstone River Sub-Basin -- Tongue to Powder Rivers

A thirty-mile reach of the Yellowstone River and the Sunday Creek drainage to the north of the river are the major streams in this sub-basin. Sunday Creek is intermittent; however, relatively high flows can be obtained in Sunday Creek during periods of snowmelt and runoff from rainstorms (probably exceeding 100 cfs at times). The remaining streams in the subbasin possess small drainage areas and are intermittent in nature; these streams were not sampled during this study.

The USGS maintains continuous-recording, discharge measuring stations on the Yellowstone River near Miles City below the confluence with the Tongue River and upstream from the confluence with the Tongue. This water quality data was supplemented through samples collected by the Water Quality Bureau (WQB) at sites in the lower Yellowstone Basin near the USGS flow station.

These analyses of waters from Sunday Creek and the Yellowstone River (Table 18) suggest that waters in Sunday Creek are of a poorer quality than those in the Yellowstone. Specific conductances (SC), dissolved solids (CDS), and SAR values are markedly higher in the Sunday Creek. Common constituent data (Table 19) shows Sunday Creek can best be classified as having a sodium-sulfate-type water. Table 20 show nutrient and metal levels in this sub-basin.

The chemical character of the Yellowstone River is related to flow with a general tendency for waters to be predominantly calcium-bicarbonate-sulfate during the spring high flow while predominantly calcium-sodium-sulfate during low flows. Sunday Creek is quite distinct in the lower Yellowstone Basin for its high chloride concentrations. This is evident in two of the three samples collected and could indicate a sodium-chloride-sulfate-type of water for the stream during most of the year.

Table 18

Chemical analysis of water collected in the Yellowstone River Sub-Basin--Tongue to Powder Rivers--field parameters.

Station	Date	Flow	Temp	pH	DO	BOD	F.C.	Turb	TSS	SC	TA	TH
Yellowstone River												
near Miles City(1)	6/3/70	31100	17.0	7.9	----	----	------	----	-----	439	----	154
	6/7/71	32000	15.0	8.1	----	----	------	----	-----	403	----	140
	6/7/72	48400	19.0	6.8	----	----	------	----	-----	247	----	86
	12/9/68	7640	0.0	7.7	----	----	------	----	-----	702	----	234
	12/2/69	6800	1.0	7.9	----	----	------	----	-----	764	----	255
	12/7/70	6840	0.5	7.0	----	----	------	----	-----	668	----	230
	12/1/71	9600	2.5	8.4	----	----	------	----	-----	682	----	230
	9/9/69	6900	20.0	8.1	----	----	------	----	-----	724	----	241
	9/9/70	6610	17.0	7.6	----	----	------	----	-----	625	----	201
	9/1/71	10300	22.0	7.6	----	----	------	----	-----	534	----	160
	9/12/72	10400	15.0	8.2	----	----	------	----	-----	475	----	160
at Miles City (2)	7/16/73	11100	24.7	---	9.0	1.9	7	14	-----	456	114	165
	3/31/74	9300	8.7	8.38	11.1	1.1	0	6	14.0	844	164	292
	4/25/74	11800	17.0	8.21	9.1	2.1	108	42	116	756	155	259
	(a) 6/10/74	35100	12.8	7.83	8.0	3.2	------	220	926	465	93	145
	(b) 6/10/74	35100	13.6	7.58	8.7	3.8	------	185	760	459	100	152
	9/24/74	8310	17.0	8.31	----	----	0	----	6.5	617	137	194
	10/3/74	8160	----	8.39	10.3	----	------	----	-----	673	155	224
	10/16/74	8910	10.0	8.51	11.4	----	------	----	34.5	660	156	212
	(c) 10/16/74	0	8.5	8.31	11.0	----	------	----	33.7	775	172	242
Sunday Creek	3/31/74	0.6	9.6	8.41	10.7	1.4	0	4	10.0	2250	228	269
	5/20/74	75E	11.0	8.21	10.3	4.3	1030	210	1004	3274	180	331
	10/16/74	0	8.5	8.13	11.5	----	------	----	42.5	2367	505	247

(1) above Tongue River (USGS); (2) below Tongue River (WQB); (a) left bank; (b) right bank; (c) backwater.

Table 19

Chemical analysis of water collected in the Yellowstone River Sub-Basin--Tongue to Powder Rivers--common constituents.

Station	Date	Lab pH	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	CDS	SAR
Yellowstone River													
near Miles City(1)	6/3/70	7.9	39	14	30	2.6	142	0	91	3.2	.3	265	1.1
	6/7/71	8.1	36	12	29	1.9	123	0	98	3.9	.3	255	1.1
	6/7/72	6.8	23	7	15	1.5	83	0	47	2.8	.3	150	0.7
	12/9/68	7.7	57	22	61	3.9	189	0	202	9.6	.4	479	1.7
	12/2/69	7.9	61	25	69	4.4	196	0	223	9.0	.6	449	1.9
	12/7/70	7.0	58	21	55	4.1	192	0	190	9.8	.4	443	1.6
	12/1/71	8.4	59	20	61	3.3	138	41	190	9.7	.4	464	1.8
	9/9/69	8.1	59	23	70	4.3	196	0	210	6.8	.5	489	2.0
	9/9/70	7.6	51	18	54	4.1	178	0	166	9.2	.5	401	1.7
	9/1/71	7.6	41	15	46	3.4	167	0	130	8.1	.9	340	1.6
	9/12/72	8.2	38	15	37	2.7	151	0	110	5.8	.5	293	1.3
at Miles City(2)	7/16/73	8.50	39	16.5	35	---	132	4	118	4.1	.31	350	1.2
	3/31/74	8.70	69	29	75	---	190	5	261	9.1	---	638	1.9
	4/25/74	8.10	65	23	63	---	189	0	227	9.6	---	578	1.7
	(a) 6/10/74	7.80	39	11.5	42	---	113	0	124	5.8	---	337	1.5
	(b) 6/10/74	7.80	43	11.2	40	---	122	0	120	5.5	---	342	1.4
	9/24/74	<8.30	52	16	61	---	167	0	161	8.0	---	465	----
	10/3/74	8.30	52	23	58	---	189	0	185	7.4	---	515	1.7
	10/16/74	8.30	55	18.2	60	---	188	1	161	7.9	---	493	1.8
	(c) 10/16/74	8.10	56	25	70	---	210	0	195	7.5	---	565	2.0
Sunday Creek	3/31/74	8.50	64	27	460	---	266	6	470	374	---	1667	12.2
	5/20/74	8.30	81	31	563	---	219	0	570	556	---	2021	13.5
	10/16/74	8.0	53	28	485	---	616	0	745	0.6	---	1948	13.4

(1) above Tongue River (USGS); (2) below Tongue River (WQB); (a) left bank; (b) right bank; (c) backwater.

Table 20
Chemical analysis of water collected in the Yellowstone River Sub-Basin--Tongue to Powder Rivers--nutrients and metals.

Station	Date	NO_3	PO_4	Fe	Mn	Cu	Zn	As	B	Cd	Cr	Hg	Pb	V
Yellowstone River														
near Miles City (1)	6/3/70	.05	---	.61	---	----	----	----	.09	----	----	----	----	---
	6/7/71	.04	.09	.04	0	----	----	----	.06	----	----	----	----	---
	6/7/72	.38	.01	.08	.01	----	----	----	.12	----	----	----	----	---
	12/9/68	2.2	---	.18	---	----	----	----	.17	----	----	----	----	---
	12/2/69	.15	---	.05	---	----	----	----	.22	----	----	----	----	---
	12/7/70	---	.02	.06	---	----	----	----	.15	----	----	----	----	---
	12/1/71	.23	.02	.01	.01	----	----	----	.15	----	----	----	----	---
	9/9/69	.10	---	.09	---	----	----	----	.14	----	----	----	----	---
	9/9/70	.01	.02	---	---	----	----	----	.14	----	----	----	----	---
	9/1/71	.34	.06	.03	.01	----	----	----	.17	----	----	----	----	---
	9/12/72	.01	0	.02	0	----	----	----	.13	----	----	----	----	---
at Miles City (2)	7/16/73	.89	.01	---	---	<.01	0.03	<.01	---	<.01	----	----	<.01	---
	3/31/74	.32	.06	.30	.03	<.01	<.01	<.01	---	<.01	----	<.001	----	---
	4/25/74	.78	.11	1.8	.12	0.01	0.02	----	.14	<.001	<.01	<.001	----	0.22
	(a) 6/10/74	.93	.15	11	.44	0.01	0.06	<.001	---	<.001	----	<.001	----	---
	(b) 6/10/74	.67	.12	.97	.51	<.01	0.06	<.001	---	<.001	----	<.001	----	---
	9/24/74	---	---	.38	.03	<.01	<.01	----	---	<.001	----	----	----	<.05
	10/3/74	.13	.21	.32	.01	0.01	<.01	0.006	.22	<.001	<.01	----	<.11	<.05
	10/16/74	1.1	.15	.4	.04	<.01	0.02	.03	---	<.001	<.01	----	<.01	---
	(c) 10/16/74	.66	.15	1.6	.04	<.01	<.01	0.006	---	<.001	<.01	----	<.01	---
Sunday Creek	3/31/74	0	.03	.26	.02	<.01	<.01	<.01	---	<.01	----	<.001	----	---
	5/20/74	.47	.03	12	.28	0.03	0.08	----	---	<.001	----	<.001	----	---
	10/16/74	20	.58	.60	.04	0.02	<.01	0.001	---	<.001	<.01	----	<.01	---

(1) above Tongue River (USGS); (2) below Tongue River (WQB); (a) left bank; (b) right bank; (c) backwater.

Total suspended solids (TSS) and specific conductance (SC) in the Yellowstone River are flow related. As flows increase SC declines while TSS increases (Table 18). Unique, however, is Sunday Creek in this sub-basin with an increase in both SC and TSS with increase in flow (Table 18). The high flow in May occurred during an extended period of rain. The increases in SC was probably due to a "flushing" of the stream and its drainage area after a long period of little precipitation and stream discharge. Such "flushing periods" at high flow are possibly characteristic of small, intermittent streams in semi-arid climates.

Little Powder River Sub-Basin

This sub-basin of the Lower Yellowstone River is small since only a small portion of the Little Powder River drainage is located within Montana. Although this river has an extensive drainage area, it is intermittent (zero flows have been recorded) (Table 21). Other tributary creeks in the sub-basin are small with small drainage areas and were not sampled during this study. A monitoring of the Belle Creek tributary of the Little Powder River has been suggested, however, due to the recent oil developments in this region.

The USGS, until recently, has maintained a flow measuring station on the Little Powder River near Broadus, Montana. However, no water quality data was collected at this station. The WQB sampled this stream in 1974 at locations near the USGS flow station. The USGS did collect water quality information for one year at an upstream location near the Montana-Wyoming border (Ref. 1).

Water quality in the Little Powder River (Table 21 & 22) is relatively poor with high hardness and SC, CDS, and SAR values. Turbidities are consistently high in the Little Powder River even at low flow periods. This river has a distinctive and consistent sodium-sulfate-type water. Bicarbonate is a common anion in the river, but is exceeded by sulfate by a factor of 1.7 to 11.4 and chloride concentrations are low. Nutrient and metals data are shown in Table 23.

Powder River Sub-Basin

Samples were collected from the Powder River upstream (1) near the Montana-Wyoming state line (near Moorhead) and (2) at Broadus, (3) near Powderville, (4) at Locate, and (5) near its mouth (near Terry). The Powder River is the major tributary to the Yellowstone River within the Lower Yellowstone Baisn. Mizpah Creek was sampled at three locations -- (1) near its headwaters at Olive, (2) near Volborg, and (3) near its confluence with the Powder River at Mizpah. The USGS has recently installed a flow gaging station on Mizpah Creek in the vicinity of Mizpah. On the Powder River, the USGS maintains flow stations at Moorhead and near Locate. Considerable water quality information is available from the USGS site at Moorhead (Ref. 1, 3); in addition, some early water quality data is available from their site at Locate (Ref. 6). Both these sites are currently active as flow, water quality, and sediment monitoring sites (Table 24, 25, 26). Due to the lack of data for the downstream location near Locate, the WQB sampling program on the Powder River stressed the lower reaches of the river.

Table 21
Chemical analysis of water collected in the Little Powder River Sub-Basin--field parameters.

Station	Date	Flow	Temp	pH	DO	BOD	F.C.	Turb	TSS	SC	TA	TH
Little Powder River												
at state line	5/12/69	33	19.0	8.2	----	----	------	----	-----	2670	----	926
	5/26/70	55	15.0	7.8	----	----	------	----	-----	1370	----	398
	7/31/69	9.2	23.0	7.8	----	----	------	----	-----	1300	----	374
	2/25/70	17	----	7.3	----	----	------	----	-----	1120	----	263
	4/28/70	12	----	8.0	----	----	------	----	-----	2160	----	560
	9/2/69	0.4	26.0	8.3	----	----	------	----	-----	3510	----	905
	10/2/69	0.1	15.5	7.5	----	----	------	----	-----	3980	----	922
	1/23/70	0.6	0.0	8.0	----	----	------	----	-----	4660	----	1310
near Broadus	2/21/74	60E	0.0	7.79	12.3	5.2	0	49	100	1846	262	467
	5/19/74	45E	13.8	8.11	9.6	2.3	180	28	74.5	3003	371	698
	8/8/74	0	23.0	8.32	8.6	5.2	168	31	54.0	3210	251	738
	9/24/74	0	11.9	7.95	7.1	6.7	0	30	40.0	4056	374	831
	10/31/74	0.1	10.2	8.21	8.9	4.2	>1000	----	26.0	2245	388	326

Table 22

Chemical analysis of water collected in the Little Powder River Sub-Basin--common constituents.

Station	Date	Lab pH	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	CDS	SAR
Little Powder River													
at state line	5/12/69	8.2	170	122	330	15	402	0	1240	7.3	0.4	2090	4.7
	5/26/70	7.8	82	47	156	12	166	0	580	5.2	1.4	977	3.4
	7/31/69	7.8	85	39	151	12	165	0	540	4.2	0.5	924	3.4
	2/25/70	7.3	56	30	152	8.9	176	0	445	4.1	1.2	791	4.1
	4/28/70	8.0	114	67	308	8.3	281	0	960	9.0	2.1	1620	5.7
	9/2/69	8.3	160	123	580	19	339	4	1740	14	0.6	2810	8.4
	10/2/69	7.5	138	140	690	19	189	0	2160	16	0.5	3260	9.9
	1/23/70	8.0	258	162	805	22	732	0	2410	17	0.8	4050	9.7
near Broadus	2/21/74	8.20	93	57	247	----	320	0	686	16.2	---	1420	5.0
	5/19/74	8.30	128	92	456	----	453	0	1190	45	---	2364	7.5
	8/8/74	8.19	127	102	650	14.5	306	0	1810	0.8	0.42	3011	10.4
	9/24/74	8.32	143	115	720	18.5	447	5	1917	20	0.41	3386	10.9
	10/31/74	8.30	66	39	410	7.5	473	0	820	1.0	0.23	1818	9.9

Table 23

Chemical analysis of water collected in the Little Powder River Sub-Basin--nutrients and metals.

Station	Date	NO_3	PO_4	Fe	Mn	Cu	Zn	As	B	Cd	Cr	Hg	Pb	V
Little Powder River														
at state line	5/12/69	.2	---	.05	---	----	----	----	.18	----	----	----	----	---
	5/26/70	.6	---	.10	---	----	----	----	.14	----	----	----	----	---
	7/31/69	.8	---	.08	---	----	----	----	.11	----	----	----	----	---
	2/25/70	.5	---	.11	---	----	----	----	.09	----	----	----	----	---
	4/28/70	.6	---	.16	---	----	----	----	.12	----	----	----	----	---
	9/2/69	.1	---	.13	---	----	----	----	.26	----	----	----	----	---
	10/2/69	.1	---	.04	---	----	----	----	.24	----	----	----	----	---
	1/23/70	.2	---	.05	---	----	----	----	.22	----	----	----	----	---
near Broadus	2/21/74	.76	0.09	.82	.20	0.01	0.01	----	---	<.01	----	<.001	----	---
	5/19/74	0	<.03	.79	.23	<.01	<.01	----	---	<.001	----	<.001	----	---
	8/8/74	---	---	.6	.32	0.01	<.01	<.001	.18	<.001	----	----	----	---
	9/24/74	.07	0.03	.58	.43	<.01	0.01	----	.24	<.001	----	----	---	.10
	10/31/74	.13	0.03	.46	.24	<.01	<.01	0.002	---	<.001	<.001	----	<.01	---

Table 24

Chemical analysis of water collected in the Powder River Sub-Basin--field parameters.

Station	Date	Flow	Temp	pH	DO	BOD	F.C.	Turb	TSS	SC	TA	TH
Sand Creek	5/20/74	0.0	11.0	8.24	6.9	3.2	56	25	55.0	5530	783	784
Mizpah Creek												
at Olive	5/20/74	0.0	9.3	7.78	6.6	1.5	4080	2	2.6	3752	385	1632
near Volborg	2/22/74	1.5	1.8	7.62	9.8	4.7	10	18	25.0	1989	291	391
	5/20/74	0.8	10.3	7.89	10.0	3.1	196	7	15.0	3020	428	626
at Mizpah	2/21/74	12.3	0.3	7.58	12.2	6.6	0	36	70.0	1674	252	254
	7/10/74	0.4	25.0	----	----	----	50	60	78.0	2092	310	282
	8/9/74	0.0	15.5	9.10	7.9	4.9	300	37	49.0	4850	507	328
	9/25/74	0.0	14.5	8.69	9.1	6.2	0	----	37.0	8391	388	685
Sheep Creek	8/9/74	0.0	16.0	9.33	12.1	7.1	60	180	-----	5010	628	256
Powder River												
at Moorhead	6/16/53	5070	21.0	6.8	----	----	------	----	-----	1490	----	838
	3/19/56	2333	6.5	7.8	----	----	------	----	-----	864	----	318
	6/8/71	2000	16.5	7.5	8.0	2.2	2400	----	-----	950	----	260
	3/1/72	4930	0.5	7.5	9.2	7.0	100	----	-----	850	----	340
	4/4/72	486	10.0	7.8	7.0	2.1	140	----	-----	1750	----	580
	6/8/72	1610	25.5	7.8	6.0	5.8	4100	----	-----	1700	----	460
	9/3/53	28.0	19.5	7.7	----	----	------	----	-----	1480	----	586
	8/28/56	15.0	19.0	8.0	----	----	------	----	-----	1380	----	550
	8/20/70	8.0	19.0	8.3	9.0	2.3	29	----	-----	5000	----	1110
	8/3/71	46	21.5	8.2	8.6	1.3	55	----	-----	2250	----	720
	9/2/71	7.7	28.5	8.5	7.6	0.7	24	----	-----	2050	----	790
	1/11/72	122	0.0	7.6	6.4	1.5	5	----	-----	1950	----	700
near Moorhead	2/22/74	390E	0.2	8.02	12.4	2.7	0	36	76.0	1847	232	484
	5/19/74	880E	13.6	8.22	9.4	2.6	475	220	1223	1469	160	375

Table 24
(Continued)

Station	Date	Flow	Temp	pH	DO	BOD	F.C.	Turb	TSS	SC	TA	TH
Powder River												
at Broadus	7/3/73	550	26.0	----	7.5	1.9	240	220	-----	1340	155	336
	2/21/74	390E	0.0	7.99	12.5	4.0	10	170	793	1688	209	440
	5/20/74	880E	11.3	8.12	9.6	2.6	1170	180	1668	1467	154	390
	9/24/74	220	13.2	8.20	9.5	3.9	0	----	266	1525	200	470
	10/31/74	290	10.0	8.30	9.2	3.0	190	----	972	1950	209	493
near Powderville	2/22/74	450E	0.3	7.89	12.4	3.9	60	75	250	1720	218	431
	8/8/74	54	23.5	8.37	8.2	2.4	70	42	54	1818	190	576
near Locate	3/29/51	3680	0.5	7.6	----	----	------	----	-----	1250	----	----
	3/30/52	22100	1.0	8.4	----	----	------	----	-----	420	----	----
	6/18/53	5393	20.0	7.0	----	----	------	----	-----	1230	----	880
	3/21/60	11470	1.5	7.4	----	----	------	----	-----	676	----	328
	8/19/59	1.4	----	7.7	----	----	------	----	-----	2490	----	1261
	8/24/60	1.0	----	7.6	----	----	------	----	-----	2790	----	1331
	9/2/61	1.0	----	8.1	----	----	------	----	-----	2630	----	1169
at Locate	2/21/74	450	0.0	7.40	12.8	4.6	10	120	275	1745	219	422
	7/10/74	166	25.0	8.02	7.6	5.7	830	450	1100	2230	195	580
	8/9/74	54	18.8	8.50	10.1	4.5	220	110	169	2000	218	514
near Terry	7/17/73	67	23.0	----	7.9	2.1	68	61	-----	2309	191	549
	4/25/74	2300	18.1	7.57	5.4	2.9	144	>1000	62800	2998	209	802
	9/23/74	184	17.3	8.11	----	----	270	400	700	1483	202	485
	10/2/74	208	----	8.12	10.3	----	------	----	484	1580	191	482

Table 25
Chemical analysis of water collected in the Powder River Sub-Basin--common constituents.

Station	Date	Lab pH	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	CDS	SAR
Sand Creek	5/20/74	8.50	115	121	1188	---	923	15	2456	0.2	---	4819	18.5
Mizpah Creek													
at Olive	5/20/74	8.20	256	241	375	---	470	0	1945	20	---	3307	4.0
near Volborg	2/22/74	8.10	71	52	333	---	355	0	769	3.0	---	1584	7.3
	5/20/74	8.30	114	83	494	---	521	0	1211	8.6	---	2432	8.6
at Mizpah	2/21/74	8.20	48	33	270	---	307	0	570	5.5	---	1235	7.4
	7/10/74	8.70	50	38	410	11.0	349	14	814	7.6	0.5	1695	10.6
	8/9/74	8.73	38	56	1090	14.4	548	34	2141	0.5	0.71	3923	26.2
	9/25/74	<8.30	92	110	2062	---	472	0	4470	44	---	7250	----
Sheep Creek	8/9/74	8.41	36	40	1160	9.7	756	5	2086	3.3	1.16	4098	31.6
Powder River													
at Moorhead	6/16/53	6.8	259	47	48	---	212	0	740	6.0	---	1330	0.7
	3/19/56	7.8	87	25	60	---	166	0	283	15	---	598	1.5
	6/8/71	7.5	65	24	----	---	---	--	360	33	---	718	----
	3/1/72	7.5	94	25	62	---	---	--	340	22	0.3	676	1.5
	4/4/72	7.8	140	57	220	---	---	--	680	120	0.5	1520	4.0
	6/8/72	7.8	120	38	----	---	---	--	650	85	----	1260	----
	9/3/53	7.7	141	57	121	---	172	0	665	9.0	----	1190	2.2
	8/28/56	8.0	140	49	95	---	140	0	605	13	----	1070	1.8
	8/20/70	8.3	228	132	----	---	---	--	----	----	----	4080	----
	8/3/71	8.2	150	85	200	---	---	--	840	90	0.4	1610	----
	9/2/71	8.5	150	100	----	---	---	--	1100	35	----	1900	----
	1/11/72	7.6	160	72	250	---	---	--	690	170	0.4	1030	4.1
near Moorhead	2/22/74	8.30	108	52	230	---	282	0	560	133	----	1367	4.5
	5/19/74	8.40	93	35	175	---	188	4	439	92	----	1025	3.9

Table 25
(Continued)

Station	Date	Lab pH	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	CDS	SAR
Powder River													
at Broadus	7/3/73	8.30	77	35	162	---	189	0	398	84	.31	946	3.8
	2/21/74	8.20	101	46	215	---	254	0	528	105	---	1250	4.5
	5/20/74	8.20	95	37	168	---	188	0	454	87	---	1029	3.7
	9/24/74	<8.30	109	48	190	---	244	0	461	72	---	1124	---
	10/31/74	8.30	105	56	238	6.0	255	0	578	147	.40	1386	4.7
near Powderville	2/22/74	8.10	100	44	220	---	265	0	513	112	---	1256	4.6
	8/8/74	8.26	119	68	198	8.2	231	0	800	2.0	.26	1426	3.6
near Locate	3/29/51	7.6	104	41	120	4.6	190	0	470	34	.5	----	---
	3/30/52	8.4	34	9	41	---	118	6	103	2.0	---	----	---
	6/18/53	7.0	143	38	95	---	176	0	515	8.0	---	----	---
	3/21/60	7.4	71	15	53	6.2	183	0	183	6.2	.3	----	---
	8/19/59	7.7	181	69	328	11.0	274	0	1300	58	.5	----	---
	8/24/60	7.6	183	79	375	11.0	269	0	1190	---	---	----	---
	9/2/61	8.1	167	70	357	---	255	0	1150	52	.5	----	---
at Locate	2/21/74	8.20	97	44	222	---	267	0	525	106	---	1263	4.7
	7/10/74	8.10	131	62	300	10	238	0	882	97	.4	1720	5.4
	8/9/74	8.36	74	80	290	7.9	256	5	910	4.5	.28	1628	5.6
near Terry	7/17/73	8.20	131	54	350	---	233	0	935	93	.39	1797	6.5
	4/25/74	7.80	190	79	375	---	254	0	1190	116	---	2205	5.8
	9/23/74	8.17	101	57	150	6.4	246	0	545	36	.32	1142	3.0
	10/2/74	<8.30	126	40	222	---	233	0	582	60	---	1263	---

Table 26
Chemical analysis of water collected in the Powder River Sub-Basin--nutrients and metals.

Station	Date	NO_3	PO_4	Fe	Mn	Cu	Zn	As	B	Cd	Cr	Hg	Pb	V
Sand Creek	5/20/74	0	.05	.95	.32	<.01	0.01	----	---	<.001	----	<.001	----	---
Mizpah Creek														
at Olive	5/20/74	0	.03	.28	.11	<.01	0.01	----	---	<.001	----	<.001	----	---
near Volborg	2/22/74	.73	.09	.48	.27	<.01	0.01	----	---	<.01	----	<.001	----	---
	5/20/74	0	.04	.65	.45	<.01	<.01	----	---	<.001	----	<.001	----	---
at Mizpah	2/21/74	1.0	.09	.68	.10	<.01	0.01	----	---	<.01	----	<.001	----	---
	7/10/74	0	.05	1.2	.06	<.01	<.01	<.001	.30	<.001	----	----	----	---
	8/9/74	---	---	.5	.02	<.01	<.01	<.001	---	<.001	----	----	----	---
	9/25/74	---	---	.50	.05	0.01	0.01	----	---	0.003	----	----	----	.80
Sheep Creek	8/9/74	---	---	6.5	.23	0.01	0.05	0.016	---	<.001	----	----	----	---
Powder River														
at Moorhead	6/16/53	0.2	---	---	---	----	----	----	.6	----	----	----	----	---
	3/19/56	1.5	---	---	---	----	----	----	.10	----	----	----	----	---
	6/8/71	.63	---	---	---	----	----	----	---	----	----	----	----	---
	3/1/72	.41	.03	---	.03	----	----	----	---	----	----	----	----	---
	4/4/72	.27	---	---	.01	0.02	0.02	0	.26	0	0	0	----	---
	6/8/72	.45	---	---	---	----	----	----	---	----	----	----	----	---
	9/3/53	5.4	---	---	---	----	----	----	.14	----	----	----	----	---
	8/28/56	8.7	---	---	---	----	----	----	.10	----	----	----	----	---
	8/20/70	.05	---	---	---	----	----	----	---	----	----	----	----	---
	8/3/71	---	---	---	.01	0.03	0.02	0	.26	0.001	0	0	.004	---
	9/2/71	---	---	---	---	----	----	----	---	----	----	----	----	---
	1/11/72	.64	---	---	.017	0.005	0.02	0.005	.28	0.001	0	<.001	----	---
near Moorhead	2/22/74	1.5	.17	.75	.05	0.01	0.01	----	---	<.01	----	<.001	----	---
	5/19/74	.17	.06	19	6.8	0.02	0.09	----	---	<.001	----	<.001	----	---

Table 26
(Continued)

Station	Date	NO_3	PO_4	Fe	Mn	Cu	Zn	As	B	Cd	Cr	Hg	Pb	V
Powder River														
at Broadus	7/3/73	.35	.02	.09	---	<.01	5.0	<.01	---	<.01	----	----	<.01	---
	2/21/74	1.3	.09	4.2	.26	0.01	0.03	----	---	<.01	----	<.001	----	---
	5/20/74	.12	.06	25	.85	0.03	0.12	----	---	<.001	----	<.001	----	---
	9/24/74	---	---	3.2	.13	0.02	0.01	----	---	<.001	----	----	----	0.05
	10/31/74	.15	.06	14	.57	0.02	0.07	0.006	---	<.001	<.01	----	<.01	---
near Powderville	2/22/74	1.3	.09	1.7	.10	0.01	0.01	----	---	<.01	----	<.001	----	---
	8/8/74	---	---	.75	.04	<.01	<.01	<.001	---	<.001	----	----	----	---
near Locate	3/29/51	5.6	---	---	---	----	----	----	---	----	----	----	----	---
	3/30/52	2.6	---	---	---	----	----	----	---	----	----	----	----	---
	6/18/53	2.0	---	---	---	----	----	----	---	----	----	----	----	---
	3/21/60	3.6	---	---	---	----	----	----	---	----	----	----	----	---
	8/19/59	0.2	---	---	---	----	----	----	---	----	----	----	----	---
	8/24/60	---	---	---	---	----	----	----	---	----	----	----	----	---
	9/2/61	0.1	---	---	---	----	----	----	---	----	----	----	----	---
at Locate	2/21/74	1.5	.09	2.0	.10	0.01	0.01	----	---	<.01	----	<.001	----	---
	7/10/74	0	.04	.34	.60	0.03	0.03	<.001	---	<.001	----	----	----	---
	8/9/74	---	---	3.4	.12	0.02	0.01	0.002	.17	<.001	----	----	----	---
near Terry	7/17/73	.28	.01	.03	---	<.01	0.03	<.01	---	<.01	----	----	<.01	---
	4/25/74	.31	.04	5.3	14	0.22	1.8	----	---	0.01	----	<.001	----	---
	9/23/74	.23	.09	7.4	.33	0.02	0.03	----	.19	<.001	----	----	----	<.05
	10/2/74	---	---	---	---	----	----	----	---	----	----	----	----	---

In addition to Mizpah Creek and the Powder River, samples were also collected from Sand Creek and Sheep Creek. These small streams are intermittent as are most minor tributaries in the sub-basin. Mizpah Creek is also intermittent regardless of its large drainage area. With its headwaters in the Big Horn Mountains, the Powder River might be viewed as a perennial stream although zero flows have occasionally been recorded. Water in this sub-basin drainage area is moderately hard and is a sodium-sulfate-type (Table 25). Although chloride concentrations are low in comparison to sulfate and bicarbonate, chloride concentrations can be high for the Powder River in relation to the other streams in the Lower Yellowstone Basin.

In general, quality of water in the Powder River and other Yellowstone River tributaries is poor with high CDS, SC, TSS, and SAR. In some cases, specific conductances remained high in this river even for samples collected at high flows.

Several strontium (Sr) analyses were completed by the USGS on samples collected from the Powder River near Moorhead (Ref. 1) with the following results:

Sample dates used in Composite	Sr. Concentration	Flow
July 22, August 20, September 25, 1969	2.43 mg/1 Sr	279 cfs
October 21, November 26, December 19, 1969	1.71 mg/1 Sr	188 cfs
January 22, February 26, March 25, 1970	1.36 mg/1 Sr	370 cfs
April 24, May 26, June 17, 1970	1.29 mg/1 Sr	2280 cfs

These data show the Powder River has a high concentration of strontium at both high and low flow. A median value for strontium of 0.06 mg/1 was found in major North American rivers by Durum and Haffty (1963) (Ref. 14) and Skougstad and Horr (1963) found a median content of strontium of 0.11 mg/1 in larger public water supplies of the United States.

Chemical analyses of water from several sites on the Powder River at similar dates (Tables 24, 25, & 26) show that no significant change in water quality occurs in the river from the Montana-Wyoming state line to its lower reaches. There is a slight improvement in quality from Moorehead to Broadus as CDS, SC, total hardness, and sulfate decline; however, these declines are followed by slight increases in concentrations from Broadus to Terry.

A major factor affecting the quality of water in the Powder River is suspended sediment. Values greater than 200 mg/1 were common in samples with an extreme value of 62,800 mg/1 measured near its mouth by the WQB during an April high flow period in 1974. About 33% of the sample volume was found to be settleable solids in April 1974. The USGS has also consistently recorded high suspended sediment concentrations for the Powder River with an extreme of 60,000 ppm obtained in 1953 (Ref. 6). Along with relatively high chlorides, high TSS values characterize the Powder in the Lower Yellowstone Basin and make this river "too thick to drink and too thin to plow (Ref. 18)."

Table 27

Effect of the Powder River (PR) on Dissolved Solid (CDS) and Suspended Sediment (TSS) Concentrations and Loading in the Yellowstone River (YR) for Three Flow Regimes (AB--above Powder, BL--below Powder).

Flow Characteristics

I. High flow Powder, low flow Yellowstone: early spring (March-April)
II. High flow Powder, high flow Yellowstone: late spring (June)
III. Low flow Powder, low flow Yellowstone: fall (September-October)

Site	Date	Flow (cfs)	TSS (mg/l)	TSS (tons/day)	Load Increase	Date	Flow (cfs)	CDS (mg/l)	CDS (tons/day)	Load Increase
I.										
YR-AB	4/25/74	11800	116	3,682		4/25/74	11800	578	18,347	
PR	4/25/74	2300	62,800	388,544		4/25/74	2300	2,205	13,642	
YR-BL	4/25/74	14500	9,450	368,597	100X	4/25/74	14500	847	33,037	1.8X
II.										
YR-AB	6/10/74	35100	843	79,595		6/7/71	32000	255	21,950	
PR	6/18/53	5393	38,100	552,723		6/18/53	5393	975	14,144	
YR-BL	6/27/72	39100	2,600	273,465	3.4X	6/27/72	39100	279	29,345	1.3X
III.										
YR-AB	9/24/74	8310	6.5	145		10/3/74	8160	515	11,304	
PR	9/23/74	184	700	346		9/23/74	184	1,142	565	
YR-BL	9/23/74	8474	15.5	353	2.4X	10/3/74	8570	517	11,919	1.05X

Since the Powder is a major tributary of the Yellowstone, it has the potential to degrade the Yellowstone River, particularly at periods of high flow in the Powder. The Powder River has a major discharge peak in March-April due to runoff from the prairie portion of its drainage and the Yellowstone River above the Powder has relatively low flows at this time (Figure 4). Effects of the Powder River would be most pronounced during this early spring period. March flow contributions of the Powder River to the Yellowstone are noticeable at the USGS discharge station near Sidney. (Figures 3 and 4). In April 1974, settleable solids in the Yellowstone River increased from near zero percent by volume at Miles City (11,800 cfs) to 8% at Fallon (14,500 cfs) below the confluence of the Powder; suspended solids increased from 116 to 9,450 mg/1 between the same sites. In contrast, at low flow periods in the Powder, the effect is less pronounced; for example, in September 1974 the Powder River at Terry had 700 mg/1 of TSS (184 cfs); and TSS in the Yellowstone River increased from 6.5 mg/1 at Miles City (8310 cfs) to 15.5 mg/1 at Terry (8474 cfs) below the confluence of the Powder River.

The Powder River has a second peak discharge in June due to mountain snowmelt in its headewaters (Figure 3). However, this coincides with the major discharge period of the Yellowstone. As a result, with the greater discharge and volume of water in the Yellowstone River and the resultant increase in dilution capacity, effects of the Powder on Yellowstone water quality are not as pronounced. Table 27.

O'Fallon Creek Sub-Basin

This creek appears to be perennial, at least near its mouth, but it does not have large flows except during periods of major runoff. Sandstone Creek and Pennel Creek are intermittent and have the largest drainage areas of the O'Fallon Creek tributaries. Sites were established by the WQB at two locations on O'Fallon Creek (an upstream site above Sandstone Creek, and a downstream site near Fallon) and at single locations on each of its two major tributaries (Tables 28, 29 & 30).

Water in O'Fallon Creek are poor quality, sodium-sulfate-type and quality is best a high flow stage and improves downstream from Ismay to Fallon. O'Fallon Creek has small flows, thus, effects on the Yellowstone River for a major portion of the year are minimal. Any pronounced effect would most likely occur in early spring when Yellowstone flows are low in contrast to relatively high in O'Fallon Creek.

Yellowstone River -- Powder River to Montana-North Dakota Border

This is the largest sub-basin in the Lower Yellowstone River Basin covering an area of approximately 4,700 square miles. There are no large tributaries entering the Yellowstone in this segment. However, numerous small streams do join the Yellowstone; most of which are intermittent. Seven of these streams were sampled by the WQB (Tables 31, 32 & 33) in the summer and fall of 1974 with flows ranging from zero to 4.5 cfs. The USGS maintains a water quality, sediment, and flow monitoring site on the Yellowstone River near Sidney, Montana. This is the only active USGS site in this sub-basin. Four sites were also established on the Yellowstone River by the WQB to

Table 28
Chemical analysis of water collected in the O'Fallon Creek Sub-Basin--field parameters.

Station	Date	Flow	Temp	pH	DO	BOD	F.C.	Turb	TSS	SC	TA	TH
Sandstone Creek	10/18/73	3.5	7.5	8.1	9.4	3.3	120	62	-----	1380	209	230
	8/9/74	0.4E	18.5	8.70	8.8	5.8	90	96	180	3300	410	384
	9/25/74	0.0	14.8	8.70	7.3	3.7	20	----	37.5	3580	494	354
Pennel Creek	8/21/74	0.0	20.0	----	----	----	------	----	-----	4530	320	1214
O'Fallon Creek near Ismay	10/18/73	6.6	9.0	8.1	9.5	2.3	0	24	-----	2695	478	400
	8/9/74	0.2E	21.0	8.99	8.0	2.9	430	88	170	3106	502	306
	8/20/74	0.5	20.0	----	----	----	------	----	-----	2990	350	180
	9/25/74	0.0	14.3	9.24	9.8	9.1	80	----	44.5	3440	272	289
at Fallon	7/17/73	15.4	26.0	----	7.8	1.7	0	4	-----	2067	305	363
	4/25/74	28.8	22.0	8.46	8.3	1.6	110	4	5.2	2890	358	514
	7/11/74	2.6	25.0	8.49	9.1	5.4	560	35	59.0	1897	275	350
	9/23/74	2.9	19.6	8.41	10.2	4.1	>1000	----	20.5	751	166	217
	10/30/74	0.9	12.0	8.34	10.4	2.4	270	<1	0	1749	390	496

Table 29
Chemical analysis of water collected in the O'Fallon Creek Sub-Basin--common constituents.

Station	Date	Lab pH	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	CDS	SAR
Sandstone Creek	10/18/73	7.60	45	28	235	---	255	0	510	9.0	.31	1084	6.7
	8/9/74	8.25	53	61	650	9.7	500	0	1370	0	.51	2645	14.4
	9/25/74	<8.30	49	56	534	---	603	0	902	57	---	2201	----
Pennel Creek	8/21/74	8.50	370	70	688	10.0	342	24	*	30	---	----	8.6
O'Fallon Creek near Ismay	10/18/73	8.20	60	61	540	---	583	0	1075	6.0	.52	2326	11.7
	8/9/74	8.61	33	54	650	10.0	549	31	1177	0.2	.52	2505	16.2
	8/20/74	8.40	72	*	565	---	403	12	1168	15	---	2235	18.3
	9/25/74	>8.30	21	53	596	---	202	44	1243	26	---	2185	----
at Fallon	7/17/73	8.50	58	53	380	---	353	10	847	11.4	.37	1712	8.7
	4/25/74	8.30	82	75	500	---	437	0	1177	18.4	---	2290	9.6
	7/11/74	8.60	50	55	400	9.0	309	13	880	16.8	.4	1733	9.3
	9/23/74	<8.30	52	21	68	---	202	0	168	8.8	---	520	----
	10/30/74	8.50	83	70	225	8.5	232	120	562	0.8	.45	1306	4.4

*Analysis in error.

Table 30
Chemical analysis of water collected in the O'Fallon Creek Sub-Basin--nutrients and metals.

Station	Date	NO_3	PO_4	Fe	Mn	Cu	Zn	As	B	Cd	Cr	Hg	Pb	V
Sandstone Creek	10/18/73	1.2	.19	1.2	---	0.01	0.02	<.01	---	<.01	----	----	0.02	---
	8/9/74	---	---	1.9	.26	<.01	0.02	0.002	---	<.001	----	----	----	---
	9/25/74	---	---	.70	.20	<.01	<.01	----	---	<.001	----	----	----	.14
Pennel Creek	8/21/74	1.3	---	---	---	----	----	----	---	----	----	----	----	---
O'Fallon Creek near Ismay	10/18/73	.25	.04	.31	---	0.01	<.01	<.01	---	<.01	----	----	<.01	---
	8/9/74	---	---	1.1	.11	<.01	0.02	<.001	---	<.001	----	----	----	---
	8/20/74	4.4	---	---	---	----	----	----	---	----	----	----	----	---
	9/25/74	---	---	.49	.08	<.01	<.01	----	---	<.001	----	----	----	.13
at Fallon	7/17/73	.39	.02	.02	---	<.01	0.05	<.01	---	<.01	----	----	0.01	---
	4/25/74	0	.04	.10	.05	0.01	0.02	----	---	<.001	----	<.001	----	---
	7/11/74	0	.04	1.6	.05	<.01	<.01	<.001	.30	<.001	----	----	----	---
	9/23/74	---	---	---	---	----	----	----	---	----	----	----	----	---
	10/30/74	4.4	.12	.12	.03	<.01	<.01	<.001	---	<.001	<.01	----	<.01	---

Table 31

Chemical analysis of water collected in the Yellowstone River Sub-Basin--Powder River to the Montana-North Dakota border--field parameters.

Station	Date	Flow	Temp	pH	DO	BOD	F.C.	Turb	TSS	SC	TA	TH
Cabin Creek	(1) 8/21/74	0.0	----	----	----	----	------	----	-----	980	183	108
	(2) 8/22/74	0.0	24.0	8.50	9.6	8.6	201	----	24.0	3670	240	460
	(2) 9/23/74	0.0	18.0	8.36	10.9	5.7	2	30	-----	4690	466	859
Cedar Creek	8/22/74	1.0E	26.5	8.90	9.0	8.5	42	----	-----	2430	124	362
	10/17/72	0.2	4.0	8.30	----	----	247	----	11.0	17500	227	4025
Sevenmile Creek	10/16/74	0.8	13.0	8.55	11.0	-----	------	----	120	1501	353	171
Hay Creek	8/23/74	0.01	15.7	----	----	----	------	----	-----	9020	380	1608
Glendive Creek	10/17/73	2.7	15.5	8.90	9.8	1.2	0	44	-----	2200	707	58
	7/11/74	4.5	----	8.30	6.9	----	>1000	8900	66000	1134	361	224
	10/30/74	1.2	14.1	9.11	11.1	3.3	150	----	26.0	2264	794	42
Fox Creek	10/17/73	4.1	8.0	8.20	10.2	2.0	170	9	-----	1185	474	495
	7/10/74	4.0	21.2	8.00	9.8	5.6	640	8	8.5	1137	319	434
	10/30/74	1.8	11.5	7.98	10.8	3.6	200	3	5.0	1163	351	439
Lonetree Creek	8/24/74	0.0	----	----	----	----	------	----	-----	9125	100	4328
Yellowstone River												
at Terry	9/23/74	8474	20.9	8.39	11.0	4.8	2	----	15.5	637	87	204
near Fallon	4/25/74	14500	16.5	8.05	7.4	3.9	104	>1000	9450	1144	173	333
	10/3/74	8368	----	8.44	10.5	----	------	----	-----	682	146	222
near Glendive	7/17/73	9760	24.6	----	8.2	----	5	20	-----	475	113	161
	10/3/74	8570	----	8.44	11.1	----	------	----	29.0	686	151	227
near Sidney	10/3/74	8570	----	8.28	10.5	----	------	----	43.0	707	158	234

(1) near headwaters; (2) near mouth.

Table 31
(Continued)

Station	Date	Flow	Temp	pH	DO	BOD	F.C.	Turb	TSS	SC	TA	TH
Yellowstone River near Sidney	10/9/67	10500	10.0	7.4	----	----	------	----	-----	760	----	243
	11/26/68	11000	2.0	7.7	----	----	------	----	-----	769	----	250
	12/29/69	8000	0.0	8.1	----	----	------	----	-----	915	----	290
	12/22/70	7400	0.5	8.4	12.2	0.7	4	----	-----	860	----	270
	12/29/71	5700	0.5	8.5	10.2	1.2	3	----	57	740	----	260
	4/6/66	6010	5.0	8.3	----	----	------	----	-----	852	----	267
	4/23/68	9160	9.0	7.7	----	----	------	----	-----	797	----	261
	4/2/69	13900	5.0	7.5	----	----	------	----	-----	844	----	255
	4/22/71	11800	8.5	8.5	9.8	1.2	13	----	-----	890	----	300
	4/19/72	12800	10.0	8.5	10.4	1.9	0	----	176	870	----	270
	6/2/66	24400	19.5	7.5	----	----	------	----	-----	274	----	90
	6/23/69	23300	21.0	8.1	----	----	------	----	-----	538	----	173
	6/22/70	39300	22.5	7.8	----	----	------	----	-----	430	----	156
	5/22/71	24700	12.0	8.3	9.4	1.6	95	----	-----	545	----	180
	6/22/71	53800	21.0	8.2	8.0	1.0	160	----	-----	330	----	100
	6/27/72	39100	20.0	8.2	7.6	1.9	1500	----	2600	430	----	120
	9/1/66	3280	18.3	7.9	----	----	------	----	-----	734	----	235
	9/22/69	6150	17.0	7.9	----	----	------	----	-----	775	----	240
	8/19/70	5060	21.0	8.1	7.4	2.2	50	----	-----	590	----	195
	9/22/70	8420	11.0	8.8	9.6	1.5	2700	----	-----	485	----	186
	9/22/71	9410	10.5	8.7	10.6	2.1	45	----	-----	540	----	170
	9/19/72	10200	18.0	8.9	9.2	2.1	24	----	344	580	121	170

Table 32

Chemical analysis of water collected in the Yellowstone River Sub-Basin--Powder River to the Montana-North Dakota border--common constituents.

Station	Date	Lab pH	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	CDS	SAR
Cabin Creek	(1) 8/21/74	7.90	20	14	320	---	223	0	576	97	---	1250	13.4
	(2) 8/22/74	8.30	71	69	730	15	293	0	1699	20	.60	2899	14.8
	(2) 9/23/74	8.43	82	159	850	10.9	527	20	2164	0	.20	3814	12.6
Cedar Creek	8/22/74	8.20	91	33	410	---	151	0	1003	78	.40	1766	9.4
	10/17/74	8.00	495	677	3550	---	277	0	8400	1893	---	15302	24.4
Sevenmile Creek	10/16/74	8.50	34	21	212	---	410	10	265	1.0	---	953	7.1
Hay Creek	8/23/74	8.60	48	361	2400	---	342	60	6100	30	---	9341	26.0
Glendive Creek	10/17/73	8.80	14	6	536	---	767	47	505	1.0	.86	1877	30.5
	7/11/74	8.20	88	6	280	9.5	441	0	402	30	---	1257	7.8
	10/30/74	9.20	10	4	555	4.0	800	83	438	0.5	.92	1895	37.3
Fox Creek	10/17/73	8/10	77	74	118	---	578	0	275	1.0	.83	1127	2.3
	7/10/74	8.40	63	67	145	5.2	379	5	412	10	.4	1087	3.0
	10/30/74	8.30	76	61	107	6.5	428	0	317	7.7	.34	1004	2.2
Lonetree Creek	8/24/74	7.80	184	939	1225	---	122	0	6656	----	---	9127	8.1
Yellowstone River													
at Terry	9/23/74	<8.30	51	19	65	---	173	0	172	8.3	---	488	----
near Fallon	4/25/74	7.70	71	38	123	---	211	0	372	31	---	847	2.9
	10/3/74	8.50	51	23	58	---	170	4	191	8.2	---	507	1.7
near Glendive	7/17/73	8.40	38	16	36	---	131	4	119	5.3	.30	349	1.2
	10/3/74	8.50	55	22	56	---	179	2	185	8.6	---	508	1.6
near Sidney	10/3/74	8.40	56	23	58	---	188	2	180	9.4	---	517	1.7

(1) near headwaters; (2) near mouth.

Table 32
(Continued)

Station	Date	Lab pH	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	CDS	SAR
Yellowstone River near Sidney	10/9/67	7.4	58	24	72	4.0	190	0	214	9.6	.4	509	2.0
	11/26/68	7.7	61	24	69	4.0	201	0	217	13	.4	524	1.9
	12/29/69	8.1	72	27	86	5.1	225	0	268	13	.5	593	2.2
	12/22/70	---	63	27	75	4.8	233	0	240	14	.5	572	1.9
	12/29/71	8.0	63	24	71	3.8	213	0	220	12	.5	512	1.9
	4/6/66	8.3	60	26	83	4.3	197	4	247	18	.4	578	2.3
	4/23/68	7.7	63	26	75	3.9	204	0	226	13	.4	533	2.0
	4/2/69	7.5	63	24	82	5.3	206	0	251	15	.4	573	2.2
	4/22/71	8.2	70	30	97	6.4	221	0	280	15	.3	620	2.4
	4/19/72	8.3	65	27	79	4.4	212	0	260	15	.4	564	2.1
	6/2/66	7.5	23	8	20	2.1	94	0	53	3.9	.2	175	0.9
	6/23/69	8.1	46	14	44	3.2	160	0	129	8.4	.6	340	1.5
	6/22/70	7.8	42	13	29	2.8	149	0	95	7.1	.4	274	1.0
	5/22/71	7.7	46	16	44	2.7	147	0	130	9.1	.3	335	1.4
	6/22/71	7.8	27	9	24	2.1	104	0	77	4.3	.2	208	1.0
	6/27/72	8.1	31	11	40	3.0	132	0	110	6.9	.3	279	1.6
	9/1/66	7.9	46	29	68	4.7	195	0	207	9.3	.5	478	1.9
	9/22/69	7.9	54	26	77	4.8	201	0	233	9.0	.5	518	2.2
	8/19/70	7.8	46	20	58	3.7	183	0	154	7.6	.5	390	1.8
	9/22/70	7.6	47	17	48	3.6	184	0	140	4.4	.5	360	1.5
	9/22/71	8.2	41	16	46	2.9	176	0	120	6.0	.8	330	1.5
	9/19/72	8.2	42	17	45	2.9	160	0	130	7.4	.4	332	1.5

Table 33
Chemical analysis of water collected in the Yellowstone River Sub-Basin--Powder River to the Montana-North Dakota border--nutrients and metals.

Station	Date	NO_3	PO_4	Fe	Mn	Cu	Zn	As	B	Cd	Cr	Hg	Pb	V
Cabin Creek	8/21/74(1)	8.0	---	---	---	----	----	----	---	----	----	----	----	---
	8/22/74(2)	1.7	.68	1.4	.15	0.03	0.02	<.001	---	<.01	----	----	----	---
	9/23/74(2)	.09	.04	.42	.17	<.01	0.01	----	.49	<.001	----	----	----	0.35
Cedar Creek	8/22/74	---	---	---	---	----	----	----	---	----	----	----	----	---
	10/17/74	8.9	.31	---	---	----	----	----	---	----	----	----	----	---
Sevenmile Creek	10/16/74	.17	.04	1.9	.1	<.01	<.01	0.006	---	<.001	<.01	----	<.01	---
Hay Creek	8/23/74	---	---	---	---	----	----	----	---	----	----	----	----	---
Glendive Creek	10/17/73	.65	.06	1.7	---	0.01	0.02	0.01	---	<.01	----	----	<.01	---
	7/11/74	.84	.09	---	---	----	----	----	---	----	----	----	----	---
	10/30/74	.27	.18	1.2	.06	0.03	<.01	0.004	---	<.001	<.01	----	<.01	---
Fox Creek	10/17/73	3.0	.07	.30	---	<.01	<.01	<.01	---	<.01	----	----	<.01	---
	7/10/74	0	<.03	.27	.04	<.01	<.01	<.001	---	<.001	----	----	----	---
	10/30/74	.31	.12	.32	.06	<.01	<.01	0.002	---	<.001	<.01	----	<.01	---
Lonetree Creek	8/24/74	---	---	---	---	----	----	----	---	----	----	----	----	---
Yellowstone River														
at Terry	9/23/74	---	---	.37	.08	0.02	0.01	----	---	<.001	----	----	----	<.05
near Fallon	4/25/74	1.4	.04	93	3.8	0.08	0.47	----	---	0.003	----	<.001	----	---
	10/3/74	.93	.24	.28	.10	0.01	<.01	----	.19	<.001	<.01	----	<.01	<.05
near Glendive	7/17/73	.12	<.01	.03	---	<.01	0.04	<.01	---	<.01	----	----	<.01	---
	10/3/74	0	<.03	.43	.05	<.01	<.01	0.006	.10	<.001	<.01	----	<.01	<.05
near Sidney	10/3/74	0	.28	.56	.06	<.01	0.01	0.003	.10	<.001	<.01	----	<.01	<.05

(1) near headwaters; (2) near mouth.

Table 33
(Continued)

Station	Date	NO_3	PO_4	Fe	Mn	Cu	Zn	As	B	Cd	Cr	Hg	Pb	V
Yellowstone River near Sidney	10/9/67	.1	---	.04	---	----	----	----	.15	----	----	----	----	---
	11/26/68	.5	---	.01	---	----	----	----	.15	----	----	----	----	---
	12/29/69	.50	.04	.055	---	----	----	----	.16	----	----	----	----	---
	12/22/70	---	---	.06	---	----	----	----	.17	----	----	----	----	---
	12/29/71	0	---	.01	.01	----	----	----	.17	----	----	----	----	---
	4/6/66	.6	---	.11	0	----	----	----	.19	----	----	----	----	---
	4/23/68	0	---	.05	---	----	----	----	.20	----	----	----	----	---
	4/2/69	.7	.08	.08	---	----	----	----	.14	----	----	----	----	---
	4/22/71	.20	.06	.02	---	----	----	----	.14	----	----	----	----	---
	4/19/72	.04	0	.03	0	----	----	----	.16	----	----	----	----	---
	6/2/66	.2	---	.58	.02	----	----	----	.09	----	----	----	----	---
	6/23/69	.1	---	.06	---	----	----	----	.02	----	----	----	----	---
	6/22/70	.03	.04	.14	---	----	----	----	.02	----	----	----	----	---
	5/22/71	.30	.12	.04	---	----	----	----	0	----	----	----	----	---
	6/22/71	.31	.09	.05	---	----	----	----	.10	----	----	----	----	---
	6/27/72	.16	.01	.07	.01	----	----	----	.10	----	----	----	----	---
	9/1/66	0	---	.01	0	----	----	----	.19	----	----	----	----	---
	9/22/69	0	.05	.09	---	----	----	----	.18	----	----	----	----	---
	8/19/70	.01	---	.002	---	----	----	----	.14	----	----	----	----	---
	9/22/70	.03	---	.008	---	----	----	----	.14	----	----	----	----	---
	9/22/71	.05	.03	.02	---	----	----	----	.17	----	----	----	----	---
	9/19/72	0	0	.02	.02	----	----	----	---	----	----	----	----	---

supplement the USGS collections. To assess downstream changes in water quality in the river, water quality runs were conducted wherein several sites on the river were sampled within a short interval of time (one to three days). Data collected by the WQB and water quality data selected from USGS records (Ref. 1, 3) are presented in Table 34 .

As in the other sub-basins of the study area, the Yellowstone River and its tributaries in this region, with one exception, have been classified as B-D_3 streams (potential warm water fisheries) (Appendix B). Waters in the tributaries are generally of poor quality and are consistently of poorer quality than the Yellowstone. Particular samples from certain of the small streams in the sub-basin have demonstrated the lowest quality of water obtained from the Lower Yellowstone Basin and from the entire Yellowstone River drainage (Ref. 20); the Lonetree Creek sample of 8/24/74; the Hay Creek sample of 8/23/74; the Cedar Creek sample of 10/17/74; and the Cabin Creek sample of 9/23/74 are notable examples (Table 32). However, the small Fox Creek tributary near Sidney is exceptional for the Lower Yellowstone Basin in having a relatively high quality water. This stream has a B-D_2 classification (Appendix) and supports a small trout fishery (Ref. 21). Fox Creek is largely perennial and has a sodium-bicarbonate-type of water. It also has relatively low suspended and dissolved solid concentrations, low specific conductances, and low SAR values; it also is comparatively cool. The remaining small streams in the region are more typical of the Lower Yellowstone Basin; that is, they are intermittent and have a sodium-sulfate-type of water with relatively high dissolved solid concentrations and relatively warm temperatures. With the exception of Glendive Creek, low suspended sediment concentrations were found in most creek samples. The individual loading on the Yellowstone River of each of these small streams in the sub-basin is probably not great given their small flows; however, taken together, there is undoubtedly a cumulative effect.

Saline seep degradation of agricultural lands is becoming a prevalent problem in portions of the northern counties of the Lower Yellowstone Basin (Table 13, Ref. 22, 23). The seeps can affect quality of surface water in saline seep areas. Surface runoff and groundwater flows from saline areas could contribute to dissolved solid concentrations and that have been observed in some streams of this sub-basin including Hay Creek, Cabin Creek, Cedar Creek, and Lonetree Creek. All of these five counties possess recognized saline seep acreages (Table 13).

The Yellowstone River contains the best quality of water in the Lower Yellowstone Basin. Prior work on the Yellowstone River in the Middle Yellowstone River Basin has indicated that the concentrations of dissolved constituents and specific conductances increase markedly downstream in the river from Huntley to Fallon (Ref. 8, 20). Part of this increase was attributed to inputs of inferior quality water from various tributaries in this middle segment; that is, the Big Horn and Tongue Rivers. Data from the WQB and USGS (Tables 31, 32 , and 34) indicate that this trend continues through the lower reach of the Yellowstone.

A water quality run was conducted on the Yellowstone River during the first week of October in 1974. Several sequential samples were taken from an upstream location near Yellowstone National Park (at Corwin Springs, Highway 89) to near the Montana-North Dakota state line (near Sidney).

TABLE 34

Chemical analysis of water collected from several sequential sites on the Yellowstone River during a water quality run in early October of 1974.

Yellowstone River: Sites and	Basin	Parameters SC	CDS	TA	TH	Na	SO^4	SAR
at Corwin Springs	Upper	226	151	58	60	19	30	1.1
at Emigrant	Upper	266	192	85	91	15	32	0.7
near Livingston (a)	Upper	259	187	85	88	16	29	0.7
near Springdale (b)	Upper	278	207	94	98	16	34	0.7
at Greycliff (c)	Upper	292	217	105	106	17	29	0.7
near Columbus (d)	Upper	286	219	106	108	15	31	0.6
near Laurel	Upper	362	259	111	125	21	56	0.8
near Billings (e)	Upper	424	316	127	156	26	76	0.9
at Custer (f)	Middle	465	344	134	172	31	91	1.0
near Miles City (g)	Lower	673	515	155	224	58	185	1.7
near Fallon	Lower	682	507	146	222	58	191	1.7
near Glendive	Lower	686	508	151	227	56	185	1.6
near Sidney	Lower	707	517	158	234	58	180	1.7
Factor increases by basin:								
	Upper	2.0X	2.2X	2.3X	2.7X	1.5X	2.8X	0.9X
	Middle	1.5X	1.6C	1.2X	1.4X	2.0X	2.2X	1.8X
	Lower	1.05X	1.00X	1.02X	1.04X	1.00X	0.97X	1.00X
Total Yellowstone Basin:		3.1X	3.4X	2.7X	3.9X	3.1X	6.0X	1.5X

(a) - (g) Major tributaries entering the Yellowstone River between a particular site and the next downstream location: (a) Shields River, (b) Boulder River, (c) Stillwater River, (d) Clarks Fork, (e) Pryor Creek, (f) Bighorn and Tongue Rivers, (g) Powder River and O'Fallon Creek.

(Table 34). These data indicate general downstream increases in dissolved constituents and specific conductances. Potential inputs and effects of the Powder River on Yellowstone water quality have been previously discussed (Powder River Sub-Basin section). At this October low flow period in the Yellowstone drainage, the data in Table 34 indicates a negligible influence of the Powder River on the Yellowstone; this substantiates the results presented in Table 27. As suggested by Table 34, at low flow periods as in October, the degradation of water quality in the Yellowstone River is apparently greater through the upper and middle reaches of the river than through its lower reach in the Lower Yellowstone Basin.

As noted, the quality of water in the Yellowstone River changes in response to flow. In general, quality improves with increased flow and as a result, water quality in the Lower Yellowstone Basin is best at high flows and in upstream locations.

The consistent downstream increases in specific conductances (Table 34) (by factors of 1.01 to 1.27 depending on month) indicate a general degradation of water quality in the river through the Lower Yellowstone Basin. Mean temperatures in the Yellowstone vary by month and range from zero to 24.0 C at Miles City and from zero to 21.8 C at Sidney. Extreme high temperatures of 26.5 C at Miles City (8/8/71) and of 29.0 C at Sidney (7/23/60) have been noted for the river (Ref. 1). These temperatures and ranges are also typical of tributary streams and are indicative of warm water aquatic habitats. Of interest in the decline in temperatures downstream in the Yellowstone from Miles City to Sidney. This decline is most pronounced in the spring, late summer, and fall and ranges from 1.6 to 3.3 C. The temperature difference in March often results in ice jams and flooding problems downstream. Temperature differences are smallest during the cold winter months when the river at both locations is at or near 0 C and during the June-July high flow periods. In high flows travel time downstream is reduced; thus, exposures of Yellowstone water to the atmosphere is less and temperatures are more uniform. (Table 35).

Table 35 also presents monthly typical mean suspended sediment concentrations for the Yellowstone River near Sidney. A distinct peak in suspended sediment in June corresponds to the major high flow period of the river. In addition, a smaller peak is evident in March which corresponds to early spring, high flow periods of the river's tributary streams (runoff from prairie drainages). Suspended sediment concentrations in these tributaries increase at this time as does their sediment loading on the Yellowstone River. This is reflected by increases in sediment concentrations within the river.

Municipal Lagoon Discharges

Chemical data for samples collected from various municipal lagoon effluents in the Lower Yellowstone Basin and from the Holly Sugar effluent at Sidney are shown in Table 36, 37. With the exception of the Holly discharge, these effluents have either a sodium-bicarbonate or sodium-sulfate type water. The chemical natures of these wastewaters relate to the initial source of municipal supply which is totally or at least partially well water in the

Table 35

Monthly mean water temperatures (°C) and specific conductances obtained at United States Geological Survey sites on the Yellowstone River near Miles City and Sidney, and mean monthly suspended sediment concentrations (mg/l) for their site near Sidney. Temperature and specific conductance means calculated for water years 1970-1972; sediment means for water year 1972.

SITE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT
						Temperature						
Miles City	9.6	4.4	0.7	0.0	0.4	4.0	9.7	15.1	18.3	21.1	24.0	16.3
Sidney	7.5	2.1	0.0	0.0	0.0	0.7	7.2	13.5	18.5	20.6	21.8	14.5
						Specific Conductance						
Miles City	672	704	722	768	738	738	740	546	329	405	547	572
Sidney	702	778	826	872	748	759	871	694	385	448	584	628
						Suspended Sediment						
Sidney	2090*	183	121	100	98	1152	232	997	1843	456	596	467

*Unusually high flows were obtained during this month: 15,407 cfs average for October, 1971 versus a 9,687 mean for water years 1967-1972.

Table 36

Chemical analysis of water collected from various lagoon systems in the Lower Yellowstone Basin--field parameters. An asterisk denotes a non-discharging system.

Station	Date	Flow	Temp	pH	DO	BOD	F.C.	Turb	TSS	SC	TA	TH
Baker	7/10/74	0.15	----	9.30	----	71.0	<100	13	60.0	1647	602	204
Belle Creek	9/18/73	<.01	----	8.70	----	78.0	4000	----	166	851	320	6
Belle Creek	10/18/74	0.02	----	9.19	----	52.0	4200	----	36.0	864	320	32
Broadus	10/31/74	<.01	----	7.75	----	91.5	350000	----	60.0	1779	551	80
Fairview	8/7/73	<.01	----	8.90	----	160	7000	29	-----	2637	825	380
Fairview	10/30/74	<.01	----	8.83	----	35.0	3000	----	90.0	1972	510	288
Fallon	10/30/74	0.06	----	9.90	----	86.0	6000	----	158	2360	1136	61
Holly Sugar	10/30/74	0.90	----	6.85	----	1160	$>10^8$	----	20.0	1578	782	905
Glendive	10/17/73	0.31	----	7.00	----	74.0	20000	----	20.0	1470	311	132
Glendive	7/11/74	0.31	----	8.00	----	87.0	9200	11	66.0	1290	313	110
West Glendive	8/22/74	0.08	----	9.25	----	73.0	20000	----	164	1988	708	139
Miles City	6/12/74	0.73	----	----	----	75.0	------	15	21.0	1832	371	234
Plevna	10/17/74	0.23	----	8.12	----	72.0	100	----	58.0	2125	770	52
Savage*	10/30/74	0	----	8.80	----	85.0	50000	----	10.0	1850	515	374
Terry	7/11/74	0.05E	----	9.11	----	47.0	2500	2	16.0	1499	545	238

Table 37

Chemical analysis of water collected from various lagoon systems in the Lower Yellowstone Basin--common constituents. An asterisk denotes a non-discharging system.

Station	Date	Lab pH	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	CDS	SAR
Baker	7/10/74	9.30	29	32	590	11	542	95	794	37	0.7	2138	18.0
Belle Creek	9/18/73	8.70	1.0	0.8	167	7	388	1	4.1	19	.13	611	30.2
Belle Creek	10/18/74	8.70	6.8	3.6	208	---	368	11	90	6.2	---	728	16.0
Broadus	10/31/74	7.60	18	8.5	442	17	672	0	370	55	4.0	1635	21.5
Fairview	8/7/73	8.90	58	57	502	---	864	70	494	80	1.2	2145	11.2
Fairview	10/30/74	7.90	41	45	390	11	622	0	525	45	.58	1697	10.0
Fallon	10/30/74	9.70	20	2.9	580	9.8	799	288	140	4.0	.21	1890	32.3
Holly Sugar	10/30/74	7.10	267	58	90	70	954	0	300	67	.86	1807	1.3
Glendive	10/17/73	7.00	22	19	275	---	379	0	283	56	.46	1071	10.4
Glendive	7/11/74	8.00	17	17	240	14	382	0	210	60	0.5	962	10.0
West Glendive	8/22/74	8.06	51	2.7	450	---	864	0	376	2.5	---	1749	16.6
Miles City	6/12/74	7.60	36	35	350	14.5	452	0	473	77	---	1460	10.0
Plevna	10/17/74	7.50	15	3.8	480	---	939	0	288	1.3	---	1737	29.0
Savage*	10/30/74	8.10	38	68	345	27	628	0	322	217	.32	1664	7.8
Terry	7/11/74	8.80	41	33	280	10	604	30	206	62	1.4	1273	7.9

in Tables 19 to 32 that exceeded the various criteria for sulfate can be summarized as follows:

	>50 mg/l	>250 mg/l	>500 mg/l	>1000 mg/l	>1500 mg/l
Yellowstone River	98%	13%	0%	0%	0%
Little Powder River	100%	100%	92%	54%	39%
Powder River	100%	94%	71%	15%	0%
Powder River tributaries	100%	100%	100%	67%	56%
O'Fallon Creek & tributaries	100%	92%	92%	50%	0%
Yellowstone River tributaries	100%	100%	59%	35%	29%
TOTAL	99%	66%	50%	23%	11%

Turbidities varied markedly within and between the streams of the Lower Yellowstone Basin. Such fluctuations were apparently related to flow as illustrated by data from the Yellowstone River wherein values varied from 6 JTU at 9300 cfs to 220 JTU at 35,100 cfs. In Sunday Creek, turbidities varied from 4 JTU at 0.6 cfs to 210 JTU at 75 cfs during an extended rain. Low turbidities were found in almost all of the streams at low flow (less than 30 JTU), values in the Little Powder and Powder Rivers were consistently greater than 30 JTU. In contrast, Fox Creek had turbidities consistently less than 10 JTU which could account for this stream's value as a trout fishery.

Extremely high suspended sediment concentrations (TSS) were obtained for some of the streams of the basin - values exceeding 1000 mg/l were found in the Yellowstone and Powder Rivers and in Sunday and Glendive Creeks. Extreme values of 62,800 and 66,000 mg/l were obtained for the Powder River and Glendive Creek respectively. Since turbidity and TSS are positively correlated, TSS also demonstrated wide differences in concentration from stream to stream in the basin.

Waters of the Lower Yellowstone Basin are not distinctly eutrophic. Generally, critical nutrient concentrations (nitrate and orthophosphate) in the streams of the basin are not of sufficient levels to cause noxious plant growths.

With the exception of chromium and mercury, all metals listed in Tables 19 to 32 were detected in some amounts in the waters of the Lower Yellowstone Basin. Of these, iron, manganese, boron, and vanadium were most consistently found in the largest concentrations. Zinc and copper also were frequently detected in the streams of the basin, but generally in much smaller amounts, commonly less than 0.09 mg/l. In addition, minute concentrations of arsenic, cadmium and lead were occasionally detected in the basin; concentrations of these three elements were less than 0.01 mg/l. In all cases, concentrations of zinc, copper, arsenic, cadmium, and lead (also chromium and mercury) were less than the recommended standards for these elements (Table 39).

Stream temperatures in the basin generally varied from near 0 C in the winter months to between 20 and 29 C during the summer periods. This range and the relatively warm summer temperatures are typical of warm water habitats in

a Northern Great Plains climate. An extreme temperature of 28.5 C was obtained for the Powder River; high temperatures were more typical of the smaller streams in the basin than of the Yellowstone River.

Dissolved oxygen (DO) is a critical parameter in the consideration of water quality, but primarily as related to biological and ecological factors rather than to human use. Dissolved oxygen concentrations within the streams of the basin during the sampling period were at or near saturation levels for the altitudes and temperatures in the region and were consistently greater than the minimum Montana requirements for marginal salmonid propagation ($B\text{-}D_2$ streams, Appendix B).

Consistently high values for DO in the streams would indicate a general absence of major organic pollution in the basin. This is confirmed by data from the numerous five-day biological oxygen demand (BOD_5) determinations made through the sampling program. This parameter was typically less than 6 mg/l for most stream samples. There were eight exceptions (11% of the samples) where BOD_5's ranged from 6.2 to 9.1 mg/l. The general absence of municipal pollution from streams in the Lower Yellowstone Basin is also illustrated by the bacteriological data. Fecal coliform/fecal strep ratios were consistently less than one which suggests a predominance of animal wastes entering the streams rather than human contamination (Ref. 12). Wide fluctuations in TSS were evident for any individual stream depending on the date of collection and flow. Concentrations of TSS in streams of the Lower Yellowstone Basin are classified as follows:

TSS Range (mg/l)	Class %	Accumulative %
10	10	10
10-25	12	22
25-50	22	44
50-100	15	59
100-400	18	77
400-800	7	84
800	17	101

The modal range of TSS in the basin is 25-50 mg/l; a median value for this parameter in the basin is 58 mg/l.

Table 38

Chemical analysis of water collected from various lagoon systems in the Lower Yellowstone Basin--nutrients and metals. An asterisk denotes a non-discharging system.

Station	Date	NO_3	PO_4	Fe	Mn	Cu	Zn	As	B	Cd	Cr	Hg	Pb	V
Baker	7/10/74	.40	7.4	.18	.08	<.01	<.01	.003	.56	<.001	----	----	----	---
Belle Creek	9/18/73	1.88	21.3	.11	---	0.01	0.04	<.01	---	<.01	----	----	0.01	---
Belle Creek	10/18/74	.13	34	.36	.04	0.02	0.03	.008	---	<.001	<.01	----	----	---
Broadus	10/31/74	47	.30	---	---	----	----	----	---	----	----	----	----	---
Fairview	8/7/73	10	9.8	.42	---	0.03	0.08	<.01	---	<.01	----	----	<.01	---
Fairview	10/30/74	17	.30	---	---	----	----	----	---	----	----	----	----	---
Fallon	10/30/74	46	.30	---	---	----	----	----	---	----	----	----	----	---
Holly Sugar	10/30/74	.04	.03	---	---	----	----	----	---	----	----	----	----	---
Glendive	10/17/73	5.5	31	.57	---	0.01	0.02	.01	---	<.01	----	----	<.01	---
Glendive	7/11/74	3.4	19	.28	.06	<.01	<.01	.004	1.2	<.001	----	----	----	---
West Glendive	8/22/74	.73	2.0	.14	.09	<.002	.013	.004	---	<.001	----	----	----	---
Miles City	6/12/74	4.0	18	---	---	----	----	----	---	----	----	----	----	---
Plevna	10/17/74	.90	9.5	---	---	----	----	----	---	----	----	----	----	---
Savage *	10/30/74	18	.30	---	---	----	----	----	---	----	----	----	----	---
Terry	7/11/74	.06	5.4	.07	.06	<.01	<.01	.003	.44	<.001	----	----	----	---

communities of the basin. Many municipal wells in the Lower Yellowstone Basin yield sodium-sulfate or bicarbonate waters; total hardness values are low in most wells. One apparent effect on this type of municipal supply as it passes through community use is a general increase in dissolved constituents including chloride. Suspended sediment concentrations are also increased, but not to a marked degree relative to concentrations within the surface waters of the basin. Values for pH are quite variable in these wastewaters and are high in some effluents.

Comparisons of the dissolved solid concentrations and SAR values in these effluents to those in streams of the Lower Yellowstone Basin indicate that the quality of wastewater is not markedly poorer in the effluents than it is in many small streams in the basin. In addition, chemical characterizations of these small streams and the effluents are quite similar. However, waters from the municipal effluents are definitely of poorer quality than waters in the Yellowstone River or in Fox Creek. Uniquely high in the municipal effluents are their fecal coliform counts, BOD_5 values, and their nutrient concentrations (nitrate and/or orthophosphate). These parameters, therefore, have the greatest potential for affecting receiving waters.

Summary

The suitability of waters of the Lower Yellowstone Basin are dependent upon the intended water use. Two factors appear to be primarily involved in the degradation of water quality in the Lower Yellowstone Basin: (1) high concentrations of dissolved solids and the associated high concentrations of particular cations and anions; (2) high concentrations of suspended sediment in some of the streams (especially at high flow periods of the year). Quality of water necessary for an agricultural or industrial use is different from that required for recreational purposes or for human consumption. In addition to the Montana Water Quality Standards (Appendix B), criteria and standards available from four other sources were reviewed in relation to the waters of the Lower Yellowstone Basin - standards established by the Public Health Service (PHS) for drinking water (Ref. 16), by the National Technical Advisory Board for surface water supplies (Ref. 17), by the Environmental Protection Agency (EPA) for public water supplies (Ref. 24), and by the California State Water Quality Control Board (CWQCB) for livestock (Ref.25).

Dissolved solid concentrations are quite variable in streams of the Lower Yellowstone Basin. Dissolved solids were consistently lowest in the Yellowstone River (less than 900 mg/l) and relatively low in Fox Creek (1000 to 1200 mg/l). In the remaining streams of the basin, including the Powder River, values commonly were greater than 1200 mg/l with high values in the range of 3500 to 10,000 mg/l. According to a USGS classification system for waters of high dissolved solids (Ref. 13), the waters of the Yellowstone River would be categorized as non-saline while those of the remaining streams would most commonly be "slightly saline" and occasionally "moderately saline". One unique and "very saline" sample was also collected in the study area - Cedar Creek on 10/17/74 (15,300 mg/l dissolved solids). With

the exception of the Yellowstone River, dissolved solid concentrations in the samples exceeded minimum standards for public supplies in almost all cases (Table 39). This standard was also exceeded in the Yellowstone at periods of low flow (i.e., at flows less than 12,000 cfs). In many smaller streams, threshold concentrations for livestock watering were often exceeded at periods of low flow, and in a few cases, waters had dissolved solid concentrations that would actually be limiting for this purpose (in Mizpah, Cedar, Hay and Lonetree Creeks, August to October of 1974).

Sodium calcium and magnesium are the dominant cations in the streams of the Lower Yellowstone Basin. Total hardness varies widely in the basin depending upon the stream and the date of collection. Extremes of 86 to 333 mg/l as $CaCO_3$ were observed for the Yellowstone River; extremes of 260 to 1331 mg/l or $CaCO_3$ were observed for the basin as a whole. According to the classification scheme of Durfor and Becker (1964), the waters in the Lower Yellowstone Basin would therefore range from "moderately hard" to "very hard" (Ref. 26). The Yellowstone River ranges from "moderately hard" at high flow periods to "very hard" at periods of low flow. All of the remaining streams in the basin, such as the Little Powder and Powder Rivers and O'Fallon and Mizpah Creeks, are classified as having "very hard" waters.

Sodium is the dominant cation throughout the Lower Yellowstone Basin. In seven samples, the stockwater threshold value for sodium was exceeded, and in three instances, this cation would be a limiting factor to this use. All of these seven samples were collected from small streams in the basin. However, for the larger streams and for 91% of the samples analyzed by the WQB, sodium would pose no toxic problems to stock.

Sodium is of added interest in relation to a stream's potential use for irrigation. High sodium absorption ratios (SAR) imply a hazard of sodium replacing calcium and magnesium in the soil with resulting damage to soil structure (Ref. 13). The high SAR values obtained for many of the samples collected from the basin suggest then that these waters could pose salinity hazards of varying degrees if used for irrigation.

Chloride and fluoride proved to be a minor constituent of the streams in the Lower Yellowstone Basin and chloride concentrations typically were less than 30 mg/l. In the Powder River, chloride values varied markedly with date and ranged from 10 to 150 mg/l. However, only in Sunday and Cedar Creeks were chloride standards for surface water supplies violated; one sample from the latter stream also exceeded the threshold concentration for stock.

Total alkalinities in the streams of the basin ranged from 87 mg/l as $CaCO_3$ (Yellowstone River) to 794 mg/l as $CaCO_3$ (Glendive Creek). However, 80% of the analyses had alkalinities between 100 and 400 mg/l; 17% of the samples had alkalinities greater than 400 mg/l (as $CaCO_3$), and all of these were from the smaller streams in the region.

High sulfate concentrations were found in some streams and in many cases, sulfate values exceeded the standards established for public and surface supplies and for stockwater (Table 39). The percentage of samples listed

TABLE 39

Selected water quality criteria and standards as compiled by four sources: Public Health Service (PHS), "Drinking Water Standards"; Environmental Protection Agency (EPA), "Public Water Supplies"; National Technical Advisory Board (NTAB), "Surface Water Criteria for Public Supplies"; and California State Water Quality Control Board (CWQCB), "Water Quality for Livestock." Concentrations are given as milligrams per liter, temperature in degrees centigrade, turbidity in JTU, and bacteria as number per 100 ml (va -- virtually absent; sat -- near saturation; vary -- variable, dependent on sampling technique or temperature; ap -- approximately).

	PHS	EPA	NTAB		CWOCB	
Constituent	Standard	Recommendation	Permissible Criteria	Desirable Criteria	Threshold Concentration	Limiting Concentration
Temperature			24			
pH		5-9	6-8.5		6-8.5	5.6-9.0
Dissolved Oxygen			3	sat		
Fecal coliforms	vary	2000	2000	20		
Turbidity	5		75	va		
Dissolved solids	500		500	200	2500	5000
Nitrate	45	ap 60	ap 60	va		
Bicarbonate					500	500
Calcium					500	1000
Chloride	250	250	250	25	1500	3000
Fluoride	vary	vary	vary	vary	1.0	6.0
Magnesium					250	500
Sodium					1000	2000
Sulfate	250	250	250	50	500	1000
Arsenic	0.01	0.1	0.05	none	1.0	
Boron			1.0	va		
Cadmium	0.01	0.01	0.01	none	5	
Chromium	0.05	0.05	0.05	none		
Copper	1.0	1.0	1.0	va		
Iron	0.3	0.3	0.3	va		
Lead	0.05	0.05	0.05	none		
Manganese	0.05	0.05	0.05	none		
Mercury		0.002				
Zinc	5.0	5.0	5.0	va		

VIII. BIOLOGICAL CONDITIONS

The Lower Yellowstone Basin includes the Yellowstone River and tributaries from Miles City, excluding the Tongue River drainage, to the Montana/North Dakota border. Waters in this basin are with a few exceptions typically warm water habitats (Ref. 1). As a result, streams in this basin do not have a good trout fishery and are generally designated as B-D_3 by the Department of Health and Environmental Sciences (suitable for growth and propagation of non-salmonid fishes) (Ref. 2). A major exception is the Fox Creek drainage in the Sidney, Montana area which is classified as B-D_2 (marginal propagation of salmonids) (Ref. 2). In addition to the warm summer temperatures (often exceeding 25° C) which restrict trout habitat, streams in the Lower Yellowstone Basin are characterized by highly variable flows, silty bottoms, and by high turbidities. There are few perennial streams in this region. The Little Powder and Powder Rivers and O'Fallon, Glendive, and Fox Creeks along with the Yellowstone River are the major streams in this basin.

Little is currently known about the aquatic ecology of the basin. Some work has been done from a fisheries standpoint on various ponds and reservoirs in the region; some fish population and benthic invertebrate work is currently being done on the lower Yellowstone River (Ref. 3). There are no known biological problems at the present time in ponds and reservoirs or in smaller streams of the basin. Suspended sediment is probably the major problem in the larger streams. This is most notable in the Powder River but is probably due primarily to natural causes such as channel and soil erosion. The journals of Lewis and Clark made mention of the turbid nature of this river long before the impact of man was felt in the basin via irrigation and grazing.

Paddlefish are the most common gamefish in the lower portion of the Yellowstone River during the spring season at which time this species is undergoing its annual spawning migration. Through the entire year, however, the sauger is the major gamefish in the basin (Ref. 4). Pallid and shovelnose sturgeon also become common below Miles City along with the buffalo and freshwater drum (sheephead). These latter two species, however, are generally viewed as trash fish. Carp are the predominant rough fish in the Yellowstone basin below Huntley (Ref. 1). The outfall from Intake Dam on the Yellowstone River northeast of Glendive provides a fair fishery for sauger, burbot (ling), and catfish in addition to the sturgeon and paddlefish (Ref. 5).

The Powder River and O'Fallon Creek tributaries of the Yellowstone in the lower basin represent minor, warm water fisheries. In the spring, catfish are abundant in the Powder River; some sturgeon and sauger are also present in this stream. However, very little is generally known about the ecology of the Powder River. The rarest fish in Montana, the sturgeon chub, is consistently found only in this drainage (Ref. 3). O'Fallon Creek contains primarily catfish with a few bullheads and some sturgeon near its mouth. A few of the smaller streams in the Lower Yellowstone Basin support minor trout fisheries. These creeks contain primarily small brook trout. Hay Creek near Glendive and Fox Creek near Sidney are two examples of such streams (Ref. 4).

Due to potential water demands associated with coal and other developments in eastern Montana, problems may ultimately develop in the Yellowstone and Powder Rivers. Increased water demands will affect stream ecology through decreasing the already low summer flows and/or by stabilizing the flow due to the installations of storage reservoirs. If storage reservoirs are not constructed, minimum flows of the Yellowstone River would be drastically reduced during the summer low periods by accessory withdrawals. Besides physical loss of habitat which would result, maximum water temperatures could increase. The temperature of the Yellowstone River at Sidney, Montana has occasionally exceeded 29° C (84° F) (Ref. 6), which is above the optimum for northern pike and emerald shiner (Ref. 7). There are about 40 other species of fish in this river with their optimum temperatures unknown. Increased maximums could and probably would change the abundance and composition of fish and other animal and plant communities in the river. At present, warm summer temperatures in the stream are near the upper tolerance limits and often above the preferred levels for various species now found in the lower Yellowstone (e.g., burbot, catfish, bullhead, and sauger) (Ref. 8). The Montana Department of Fish and Game is empowered to reserve an amount of water as deemed necessary to protect fish and wildlife in and about the streams. This agency is currently determining the minimum flows necessary for these purposes (Ref. 3).

If the flow of the Yellowstone River is stabilized by storage reservoirs, paddlefish may be lost from its lower reaches as Spring runoff apparently triggers their spawning runs. The Department of Fish and Game is currently investigating this possibility and is also trying to assess the potential effects of a stable flow in the river on waterfowl production. There are indications that occasional flooding is required for and positively correlated with Canadian goose production (Ref. 3).

Most of the biological data in the Lower Yellowstone Basin relates to fisheries work. Since the projected development of the region could ultimately influence aquatic systems, more effort is needed, not only for fisheries studies, but for investigations of such factors as benthic fauna, periphytic and macrophytic flora, productivity, tolerance limits. Such additional biological information is ecologically essential for a sound water management program in the basin.

IX. MANAGEMENT STRATEGY AND PLAN

The objective of water quality management is to maintain or enhance the quality of waters within the basin. To accomplish this, management programs and plans must be developed and implemented within the basin. After development and implementation, waters and wastewaters in the basin must be checked to determine actual effectiveness of the management program. Water quality management is an interative process; that is, a plan must be followed, the results checked, the plan modified, and the results again checked. A management strategy contains a number of elements. These are:

1. Permits.

   State and federal pollutant discharge permits are a basic tool in regulating the discharge of effluents to state waters. All discharges under the permit authority, either are or will be permitted or eliminated. The permit program regulates the quantity and quality of discharges of municipal and industrial wastes and certain agricultural wastes, including discharges from confined feeding operations and from irrigation drainage systems. The discharge permit also is used to regulate effluent from new or expanded discharges. As stream quality data are obtained, the permit can be used to insure that discharging effluents do not cause streams to exceed state water quality standards. All dischargers will be required, under the permit program, to achieve best practicable control technology not later than July 1, 1977. All publicly owned treatment works must achieve secondary treatment by July 1, 1977.

2. Intensive Surveys.

   Intensive water quality surveys are conducted for waters in the basin that have water quality problems. Objectives of intensive surveys are to determine pollution causes and potential means of elimination or abatement of pollutants. As additional water quality problems are identified within the basin, intensive surveys will be made. Intensive surveys also are conducted to determine the impact of specific wastewater discharges, land practices, or water treatment facilities that are installed in the basin.

3. Monitoring.

   Monitoring include a number of activities that provide measurement of chemical, physical and biological quality of water and changes in quality. Monitoring includes:

   (a) self-monitoring required by dischargers that are under the Pollutant Discharge Elimination System permit program

(b) compliance monitoring by the Water Quality Bureau and the EPA to ensure that permitted discharges are in compliance with allowable limits;

(c) periodic sampling and analysis of water at selected stations;

(d) aerial and ground observations of basin waters and practices or facilities that effect water quality;

(e) the use of continuous water quality recording instrumentation to obtain a continuous record of selected water quality parameters;

(f) short-duration surveys of stream segments to determine changes in quality in streams as the water progresses downstream;

(g) evaluation of water quality data to determine trends and to identify problems.

The basic objective of the monitoring effort is to determine the status of water quality and to determine variations in water quality. The monitoring network also is useful for determining the impact of activities within the basin that influence water quality. Such activities include those that potentially degrade water quality, such as logging, mining, and certain agricultural practices; and those activities that may enhance water quality, such as installation of improved treatment facilities.

4. Facilities construction, operation, and maintenance.

Federal and state grant programs are available to assist municipalities in the construction of sewage treatment facilities, which include outfall and interceptor sewers. Such facilities provide improved treatment of wastewaters and reduce the impact of wastewaters on the receiving water body. An integral part of the waste treatment facility program is adequate operation and maintenance of the facilities after construction is completed. The state requires that all operators be certified and the state provides on-the-job training and annual schools for operators.

5. Operation and maintenance.

Periodic inspections are made of municipal and industrial wastewater treatment facilities in the basin. The objective of operation and maintenance inspections is to ensure that waste treatment facilities are operated in a manner that provides the best possible treatment.

6. Information and Education.

Information is made available to the public through bureau publications, talks, technology transfer seminars, and through answering inquiries. Public hearings and environmental impact

statements are presented for important or controversial issues in the basin. Information and educational efforts are informing the public of water quality conditions in the basin and factors that can degrade water quality. This effort stresses development of a pollution prevention attitude.

7. Regulations and Guidelines.

   To prevent water quality degradation within the basin, regulations and guidelines that relate to water quality will be made available to residents of the basin through state and county organizations. This includes regulations that influence water and wastewater from subdivisions and private and public water and wastewater facilities. In addition, existing regulations may be changed or updated to control activities within the basin that will degrade water quality. The Department of Health and Environmental Sciences in cooperation with other agencies, will develop guidelines that will abate or eliminate pollution resulting from storm drainage, storm sewer discharges and non-point sources, including irrigation practices, road building, construction, logging practices, overgrazing and other practices. Land use is recognized as a dominant factor controlling water quality in the basin. Those activities which influence land use will be examined to determine how water quality degradation due to improper land uses can be eliminated to be abated.

8. Enforcement.

   Violations of Montana's laws, rules, or permits are investigated and are subject to injunction, civil penalties, or criminal penalties. The rules and regulations upon which enforcement is based are periodically reviewed and updated to insure that Montana's laws and regulations are adequate and can be properly enforced.

9. Program Coordination.

   Montana's water pollution control program will be coordinated with other state, federal and local agencies to ensure that the activities of these groups receive adequate information with respect to their water quality related activities. This includes review of proposed programs, laws, regulations and proposed technical investigations that relate to water quality.

The elements of basin water quality management described above generally are applicable to all basins. Specific steps that will be taken in the Lower Yellowstone Basin are:

1. Permits.

   Permit conditions and progress in meeting compliance schedules will be reviewed for all dischargers in the basin in FY 1976. All

permits will be reviewed prior to expiration to determine what revisions are needed for the reissued permits. All dischargers that have not received permits, but are under the NPDES or MPDES, will receive permits in FY 1976.

2. Intensive Surveys.

   In FY 1976 an intensive survey is planned to examine saline seep areas in the basin. As additional water quality problems are identified and as funding is available, additional intensive surveys will be conducted.

3. Monitoring.

   See Section XII (Monitoring and Surveillance) for specific basin strategy and plans.

4. Facilities Construction, Operation and Maintenance.

   Inadequate municipal sewage treatment has been ranked according to priority (Page 37) and will be upgraded to meet secondary treatment by July 1977. Industrial treatment of wastewater discharges will meet best practicable treatment by July 1977. Some EPA and state grant funds will be available for municipal sewage facilities. Sewage treatment plant operator training and the operators school will be available for the basin.

5. Operation and Maintenance.

   At least one inspection will be made annually of each municipal sewage treatment facility in the basin. Critical installations will be provided additional inspections when needed and facilities with special operation and maintenance problems will be provided with technical assistance.

   Major industrial dischargers are examined at least twice per year and minor dischargers are examined as needed and as manpower and funding are available.

6. Information and Education.

   The general bureau information and education program will be utilized in the basin. No specific basin programs are planned for the next year.

7. Regulations and Guidelines.

   During the next year the regulatory framework for water pollution control will be reviewed by the bureau attorney. The adequacy of the regulations to prevent pollution will be assessed.

8. Enforcement.

   Enforcement actions will be taken as needed for prosecution of violations of the state's water pollution laws and regulations.

9. Program Coordination.

   Federal, state and private organizations that have water quality related actions in the basin will be informed of the Bureau's efforts and will be requested to furnish information on these basin programs.

X. MONITORING AND SURVEILLANCE

Water quality monitoring and surveillance programs represent a major investment of time and funds. Such programs should obtain the needed information at least cost. To properly design a cost-effective monitoring system, a number of factors must be considered including:

1. Adequacy of baseline data in the basin;
2. Status of the stream as a receiving water for pollutant discharges;
3. Data needs for point source discharges under state and federal permit programs;
4. Existing and potential water quality problems;
5. Data needs for enforcement actions;
6. Available time and funding;
7. Existence of other water quality data collection programs in the area.

Flexibility in scope and intensity is an important aspect of a proposed program. A variety of factors can influence an area's water quality; these include industrial, municipal, and agricultural developments, federal and state regulations, and water transfers. With the range of developments that can occur in a basin, a long-term management strategy cannot be efficiently developed. Water quality surveillance and monitoring is directed at short-term conditions (up to five years in the future) and is revised annually.

Monitoring and surveillance recommendations are presented in this report. The detailed basin monitoring and surveillance program is developed by the Water Quality Bureau as part of the annual water pollution control program plan. Monitoring and surveillance activities are conducted by a variety of organizations including communities and industries, federal and state agencies private individuals and organizations. Commonly, acute problems such as toxic conditions causing fish kills, oil spills, etc. are recognized by basin residents or persons working in the basin.

The following is the recommended monitoring program for the Lower Yellowstone Basin.

1. Compliance Monitoring.

   The following municipal point discharges should be checked by the Water Quality Bureau to check compliance with permit conditions.

   Baker
   Belle Creek
   Broadus
   Fallon
   Glendive
   (sewage treatment facility)
   Glendive (water treatment facility)
   Miles City
   Terry
   West Glendive

Suspended solids, BOD_5, fecal coliforms, and flow will be monitored in all municipal discharges; residual chlorine will be measured where chlorination is provided. Municipal water treatment plant discharges will be monitored for aluminum, suspended residue, turbidity, flow pH, and residual chlorine.

Similarly, the following industrial discharges should be monitored by the Water Quality Bureau to check compliance with permit conditions:

Holly Sugar Corporation (three sources)
Montana-Dakota Steam Generating Plant at Sidney (five sources)
Montana-Dakota Steam Generating Plant at Glendive (four sources)
Miles City Sand and Gravel
Gary Operating Company -- Belle Creek (twenty-four sources)
Union Texas Petroleum Company -- Belle Creek
Union Texas Petroleum Company Light Ends Refinery near Baker

Frequency and parameters to be monitored for irrigaion return flows have not, as yet, been defined. Feedlots are basically designed as non-discharging facilities.

The specific bureau compliance monitoring program, including discharges, frequency and parameters is described in the Bureau's annual water pollution control plan.

2. Self-Monitoring.

All waste dischargers under MPDES permit are required to periodically sample and analyze their wastewater and report these results to the Bureau and the Environmental Protection Agency. The parameters to be monitored are specified in the conditions of the permit.

3. Water Quality Surveillance Network.

The water quality surveillance network is composed of water quality sampling stations on streams, water bodies and groundwater. Surveillance is recommended for the following streams:

Stream	Site
Yellowstone River	At Miles City
Sunday Creek	Near Miles City
Powder River	At Moorhead
Powder River	Near Broadus
Little Powder River	Near Broadus
Belle Creek	Near Belle Creek (Broadus)
Mizpah Creek	Near Mizpah
Powder River	Near Locate
Yellowstone River	Near Terry
O'Fallon Creek	Near Ismay
Sandstone Creek	Near Ismay
Cabin Creek	Near Fallon
Cedar Creek	Near Glendive
Sevenmile Creek	Near Glendive
Glendive Creek	At Glendive
Fox Creek	Near Sidney
Yellowstone River	Near Sidney

Recommended surveillance frequency varies from continuously to quarterly and parameters to be monitored generally include flow, sediment, temperature, nutrients, common ions, and coliform organisms.

The acutal basin surveillance program is described in the bureau annual water pollution control program plan. Details of sampling frequency and parameters also are described in this plan.

Biological assessment and water quality runs will be carried out at selected sites in the basin. Biological assessments involve periodic quantitative and/or qualitative benthic organism assessments. Water quality runs involve an intense instream survey of a few water quality parameters at a large number of stations. The sampling is designed to measure changes in stream quality as the water moves downstream. Sites selected for these evaluations are described in the Bureau's annual pollution control plan.

4. Aerial and Ground Surveys

Examination of streams and water bodies is done as part of the routine bureau visits to the basin. Other agencies and organizations also commonly notice stream conditions during their basin trips. Detailed aerial surveillance and actual stream examination on foot or by boat is required for selected problems.

5. Data Interpretation and Analysis

Surveillance and monitoring activities develop water quality data that must be compared with previous data, water quality standards, permit conditions, etc. Results of water quality testing must be analyzed and interpreted to understand temporal and spatial changes in water quality and determine if the sampling network is adequate to meet program objectives.

XI. COAL DEVELOPMENT

There are substantial deposits of strippable coal in the Lower Yellowstone River Basin, and there is considerable exploration and land leasing (Ref. 1). Presently, however, only one mine is producing coal in the basin, and there are no known water quality problems associated with the mine.

Water quality problems may arise either directly or indirectly from coal development, coal mining, or coal conversion plants. These facilities will have water quality problems, and increased populations in the basin will cause additional water pollution. The impact of energy developments in the Middle Yellowstone River basin will be very dependent on the type of development and will be site-specific.

The potential for water quality degradation due to energy developments including coal mining and energy conversion plants and increased populations is enormous. There is a great deal of statewide concern about the impact of such developments on both surface and groundwater quality. State land reclamation and water pollution regulations are a basic regulatory factor in controlling environmental impacts on water quality. There is considerable effort being directed at evaluation of the impact of energy developments in this portion of Montana. Presently, water quality effects of energy developments are not well understood. The development of coal, however, is in its infancy and will greatly expand within the next decade. Information obtain from existing and proposed technical studies should indicate the extent and magnitude of energy impacts on water quality. Presently, it is too early to accurately assess either the short or long-term consequences of energy development.

Many potential water pollutants due to coal mining have been identified. These include degradation of ground and surface water due to leaching of salts from spoil piles, increased sedimentation due to runoff from disturbed lands, and increased stress on the water resources due to increased populations.

Although some technical work has been done on these problems, the results to date are inconclusive and variable. Land reclamation techniques used at a mine site will affect water movement and water quality. Land reclamation is in an experimental status; thus, the impact on water quality cannot be accurately assessed.

Coal conversion processes including coal-fired power generation and gasification are another threat to water quality. These processes involve not only mining, but the conversion of coal with its attendant pollution problems. Due to the wide variety of conversion processes, water quality problems cannot be predicted. The evaluation of pollution potential will be both site and process dependent.

XII. WATER QUALITY PROBLEMS AND FUTURE NEEDS

A variety of point and non-point water pollution problems have been identified in this report and are summarized in Table . The problems originate from a variety of sources and have a variation in severity and potential for correction. This water quality management plan has generally identified the location and type of problems, and background details concerning these problems are presented in the report. Considerable additional work is needed to further define these problems, determine techniques for abatement or elimination, and implement actions to correct the problems.

Two basic elements are needed in the basin to successfully improve water quality and prevent further quality degradation. These are (1) a program of education and information to relate the problems to the public, and (2) increased funding for further technical identification of the problem and potential solution.

TABLE 40. SUMMARY OF WATER POLLUTION PROBLEMS IN THE LOWER YELLOWSTONE RIVER BASIN

Problem	Stream or Area	Status	Potential for Correction	Methods of Correction
Municipal wastewater discharges that degrade stream quality. Low to moderately severe problem.	Primarily Yellowstone River but includes other streams.	Problem decreasing. All treatment facilities on MPDES permit. Communities are upgrading treatment process.	Good. Additional grant funding needed.	Construction of secondary treatment facilities.
Industrial discharges that degrade stream quality. Low to moderately severe problem.		Problem decreasing or stable. All discharges on MPDES permit. Waste treatment at industrial facilities being upgraded.	Good. Additional effort needed to meet treatment requirements.	Construction of improved treatment facilities.
Holly Sugar Co. discharge not meeting permit condition. High BOD, coliform. Severe problem.	Yellowstone River at Sidney.	Bureau and EPA enforcement action in process. A $190,000 penalty requested.	Good	Additional wastewater treatment works needed.
Saline seep. Loss of productive land to saline groundwater. Increased stream salinity. A major problem.	Yellowstone River, Fox Creek, Sandstone Creek, Cabin Creek, Canal Creek.	Increasing. Some study effort but little corrective effort to date.	Poor to fair. An economically difficult problem. Technical corrective measures not well known.	Cropping practice changes. Land use changes. Much additional investigation of causes and potential solutions needed.
Stream pollution and habitat degradation due to confined livestock feeding and wintering operations. Problem severity low to moderate.	Many streams in basin.	Increasing. Problem not well defined. MPDES permits required on larger feedlots. Additional evaluation needed.	Good. Corrective techniques readily available. Education and information problem. Additional detailed surveys needed to pinpoint problem areas.	Stream bank fencing. Construction of runoff holding ponds. Relocation of feedlots and livestock wintering operations.

Problem	Stream or Area	Status	Potential for Correction	Methods of Correction
Irrigation return flows. Stream degradation due to runoff from agricultural lands that cause increased temperature, salinity, nutrients, pesticides and suspended sediment. Moderate to severe problem.	Primarily Yellowstone River.	Rapidly expanding irrigation is leading to more return flows. Problems need much additional investigation to determine impact.	Fair to good. Manipulation of irrigation practice involves education, informational and technical study.	Better water management. Reuse of return flows. Identification of problem areas and change in water use in these areas.
Urban runoff causing water quality degradation in streams. Low to moderately severe problem.	Primarily Yellowstone River, also other streams.	Increasing slowly by increased population. Not well understood. Primarily from larger communities.	Good. Technical methods available. Requires additional funding for treatment facilities. Treatment sites difficult to obtain.	Use of treatment ponds. Good drainage control.
Stream dewatering causing increased temperature and loss of aquatic habitat. Moderate to severe problem.	Yellowstone River and other streams.	Rapidly increasing due to irrigation and industrial diversions. Impact on streams needs much more investigation.	Fair to poor. Economics of use of diverted water conflicts with in-stream aquatic needs.	Better water management and water storage. Denial of water diversions during critical flow periods.

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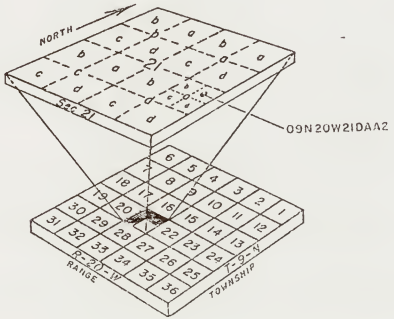
COAL DEVELOPMENT

1. Montana Energy Advisory Council, 1974, Coal Development

APPENDIX A

SYSTEM FOR GEOGRAPHIC LOCATION OF FEATURES

Wells, springs, water-sampling locations, and stream-gaging locations are assigned numbers based on the system of land subdivision used by the U. S. Bureau of Land Management. The number consists of twelve characters and describes the location by township, range, section, and position within the section. The figure below illustrates the numbering method. The first three characters of the number give the township, the next three characters the range. The next two numbers give the section number within the township, and the next three letters describe the location within the quarter section (160-acre tract) and the quarter-quarter section (40-acre tract), and the quarter-quarter-quarter section (10-acre tract). These subdivisions of the 640-acre section are designated a, b, c, and d in a counterclockwise direction, beginning in the northeast quadrant. If there is more than one feature in a 10-acre tract, consecutive digits beginning with 2 are added to the number. For example, if a water-quality sample was collected in sec.21,T.9N.,R20W, it would be numbered 09N20W21DAA2. The letters DAA indicate that the well is in the NE¼ of the NE¼ of the SE¼, and the number 2 following the letters DAA indicates there is more than one water-quality sampling location in this 10-acre tract.



Appendix B

MONTANA STATE DEPARTMENT OF HEALTH
AND
ENVIRONMENTAL SCIENCES

MAC 16-2.14(10)-S14480 WATER QUALITY STANDARDS

(1) Policy statement. The following standards are adopted to establish maximum allowable changes in water quality and establish limits for pollutants which affect prescribed beneficial uses of state waters. The department adopts as a rule the policy that best practicable treatment and control of waste, activity and flow is to be provided to maintain dissolved oxygen and overall water quality at the highest possible levels, and water temperatures, coliform bacteria concentrations, dissolved chemical substances, toxic materials, radioactivity, turbidities, color, odor and other deleterious substances at the lowest possible levels.

(2) Application of standards. The water quality standards are composed of water-use classifications [section (4)], water-use descriptions and specific water quality criteria [section (5)], and general water quality criteria [section (6)].

(a) General water quality criteria apply to all state waters except where in this rule specific water quality criteria are more applicable to a specific water-use classification.

(b) In order to carry out the objective of the rule, existing discharges to state waters shall be brought into compliance with the standards as soon as practicable, and in no case later than three years from the effective date of the rule.

(3) Definitions. Unless statutory definition or the context otherwise requires in this rule:

"Conduit" means any artificial or natural duct, either open or closed, for conveying liquids or other fluids.

"Dewatered stream" means a perennial or intermittent stream whose water has been removed for one or more beneficial uses.

"EPA" means the U. S. Environmental Protection Agency.

"Intermittent stream" means a stream or portion of a stream that flows only in direct response to precipitation; it receives little or no water from springs and no long-continued supply from melting snow or other sources.

"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservation practices have been applied. Conditions resulting from dams in existence as of July 1, 1971 are natural.

"Mixing zone" means that volume of state water wherein any pollutant may exceed allowable water quality standards.

"Pesticide" means insecticides, herbicides, rodenticides, fungicides or any substance or mixture of substances intended for preventing, destroying, controlling, repelling, altering life processes, or mitigating any insects, rodents, nematodes, fungi, weeds and other forms of plant or animal life.

"Residue" means oils, floating solids and sludge deposits.

"Sediment" means solid material settled from suspension in a liquid; mineral or organic solid material that is being transported or has been moved from its site of origin by air, water or ice and has come to rest on the earth's surface, either above or below sea level; or inorganic or organic particles originating from weathering, chemical precipitation or biological activity.

"Settleable solids" means inorganic or organic particles that are being transported or have been transported by water from the site or sites of origin and are settled or are capable of being settled from suspension.

"Sewer" means a pipe or conduit that carries wastewater or drainage water.

"State waters" means any body of water, irrigation system or drainage system, either surface or underground. This section shall not apply to irrigation waters where the waters are used up within the irrigation system and said waters are not returned to any other state waters. The term "state waters" as used in this rule does not include underground water.

"Storm sewer" or "storm drain" means a sewer that carries storm water and surface water, street wash and other wash waters, or drainage but excludes sewage and industrial wastes.

"True color" means the color of water from which the turbidity has been removed.

"Turbidity" means a condition in water or wastewater caused by the presence of suspended matter resulting in the scattering and absorption of light rays.

(4) Water-use classifications.

MISSOURI BASIN

Yellowstone River Drainage

Yellowstone River:

Yellowstone River drainage from the confluence of the Tongue River to the North Dakota state line except the tributary listed below ..... B-D_3

Fox Creek drainage near Sidney ..... B-D_2

(5) Water-use description and specific water quality criteria.

(a) General. Specific water quality critieria, along with criteria in section (6) protect the beneficial water uses set forth in the water-use descriptions for the following classifications of water. Criteria for organisms of the coliform group are based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period analyzed by the most probable number or equivalent membrane filter methods. The metal limits on the Clark Fork River [section (6)] are to govern when this section (5) imposes a conflicting requirement with that criteria.

(e) B-D_2 classification.

(1) Water-use description. The quality is to be maintained suitable for drinking, culinary and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection and any

additional treatment necessary to remove naturally present impurities; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

(ii) Specific water quality criteria.

(aa) The average number of organisms in the fecal coliform group is not to exceed 200 per 100 milliliters nor are 10 percent of the total samples during any 30-day period to exceed 400 fecal coliforms per 100 milliliters. The average number of organisms in the coliform group is not to exceed 1,000 per 100 milliliters nor are 20 percent of the samples to exceed 1,000 coliforms per 100 milliliters during any 30-day period.

(ab) Dissolved oxygen concentration is not to be reduced below 7.0 milligrams per liter from October 1 through June 1 nor below 6.0 milligrams per liter from June 2 through September 30.

(ac) Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 9.0 is to be less than 0.5 pH unit. Natural pH outside this range is to be maintained without change. Natural pH above 7.0 is to be maintained above 7.0.

(ad) The maximum allowable increase above naturally occuring turbidity is 10 Jackson Candle Units, except as is permitted in the general water quality critiera.

(ae) A 1° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 66° F; within the naturally occuring range of 66° F to 66.5° F, no discharge is allowed which will cause the water temperature to exceed 67° F; and where the naturally occurring water temperature is 66.5° F or greater, the maximum allowable increase in water temperature is 0.5° F. A 2° F per hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55° F, and a 2° F maximum decrease below naturally

occurring water temperature is allowed within the range of 55° F to 32° F.

(af) No increases above naturally occurring concentrations of sediment, settleable solids or residues, which adversely affect the use indicated, are allowed.

(ag) Concentrations of toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metals, after treatment for domestic use, are not to exceed the recommedned limits contained in the 1962 U. S. Public Health Service Drinking Water Standards or subsequent editions, and no increase of more than 10 percent of the concentration present in the receiving water is permitted; maximum allowable concentrations are to be less than acute or chronic problem levels as revealed by bioassay or other methods.

(ah) True color is not to be increased more than five units above naturally occurring color.

(f) B-D_3 classification.

(i) Water use description. The quality is to be maintained suitable for drinking, culinary and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection and any additional treatment necessary to remove naturally present impurities; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

(ii) Specific water quality criteria.

(aa) The average number of organisms in the fecal coliform group is not to exceed 200 per 100 milliliters nor are 10 percent of the total samples during any 30-day period to exceed 400 fecal coliforms per 100 milliliters. The average number of organisms in the coliform group is not to exceed 1,000 per 100 milliliters nor are 20 percent of the samples to exceed 1,000 coliforms

per 100 milliliters during any 30-day period.

(ab) Dissolved oxygen concentration is not to be reduced below 5.0 milligrams per liter.

(ac) Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 9.0 is to be less than 0.5 pH unit. Natural pH outside this range is to be maintained without change. Natural pH above 7.0 shall be maintained above 7.0.

(ad) The maximum allowable increase above naturally occurring turbidity is 10 Jackson Candle Units, except as is permitted in the general water quality criteria.

(ae) A 3° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 77° F; within the naturally occurring range of 77° F to 79.5° F, no thermal discharge is allowed which will cause the water temperature to exceed 80° F; and where the naturally occurring water temperature is 79.5° F or greater, the maximum allowable increase in water temperature is 0.5° F. A 2° F per hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55° F, and a 2° F maximum decrease below naturally occurring water temperature is allowed within the range of 55° F to 32° F.

This applies to all waters in the state classified B-D_3, except from the Billings water supply intake to the water diversion at Intake, a 3° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 79° F; within the range of 79° F to 81.5° F, no thermal discharge is allowed which will cause the water temperature to exceed 82° F; and where the naturally occurring water temperature is 81.5° F or greater, the maximum allowable increase in water temperature is 0.5° F.

From the water diversion at Intake to the North Dakota state line, a 3° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 82° F; within the range of 82° F to 84.5° F, no thermal discharge is allowed which will cause the water temperature to exceed 85° F; and where the naturally occurring water temperature is 84.5° F or greater, the maximum allowable increase in water temperature is 0.5° F.

(af) No increases above naturally occurring concentrations of sediment, settleable solids or residues, which adversely affect the use indicated, are allowed.

(ag) Concentrations of toxic or other deleterious substances, pesticides and organic materials including heavy metals, after treatment for domestic use, are not to exceed the recommended limits contained in the 1962 U. S. Public Health Service Drinking Water Standards or subsequent editions, and no increase of more than 10 percent of the concentration present in the receiving water is permitted; maximum allowable concentrations are to be less than acute or chronic problem levels as revealed by bioassay or other methods.

(ah) True color is not to be increased more than five units above naturally occurring color.

(6) General water quality criteria.

(a) The degree of waste treatment required to restore and maintain the standards is to be determined by the department and is to be based on the following.

(i) The state's policy of nondegradation of existing high water quality as described in Section 49-4808.2, R.C.M. 1947.

(ii) Present and anticipated beneficial uses of the receiving water.

(iii) The quality and nature of flow of the receiving water.

(iv) The quantity and quality of the sewage, industrial waste or other waste to be treated.

(v) The presence or absence of other sources of pollution on the same watershed.

(b) Sewage is to receive a minimum of secondary treatment as defined by EPA in accordance with requirements set forth in the Federal Water Pollution Control Act Amendments of 1972.

(c) Industrial waste is to receive, after maximum practicable in-plant control, a minimum of secondary treatment or equivalent (reduction of suspended solids and organic materials where present in significant quantities, effective disinfection where bacterial organisms of public health concern are present, and control of toxic or other deleterious substances) before discharge into state waters.

(d) For design of disposal systems, stream flow dilution requirements are to be based on minimum consecutive seven-day average flow which may be expected to occur on the average of once in ten years. When dilution flows are less than the above design flow at a point discharge, the discharge is to be governed by the permit conditions developed for the discharge through the waste discharge permit program.

(e) State surface waters are to be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will:

(i) Settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines.

(ii) Create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials.

(iii) Produce odors, colors or other conditions as to create a nuisance or render undesirable tastes to fish flesh or make fish inedible.

(v) Create conditions which produce undesirable aquatic life.

(f) No wastes are to be discharged and no activities conducted such that the wastes or activities, either alone or in combination with other wastes

or activities, will violate, or can reasonably be expected to violate, any of the standards; (e.g., in a reach of stream classified B-D_1, the total allowable cumulative increase to naturally occurring turbidity conditions in the reach is 5 Jackson Candle Units).

(g) No wastes are to be discharged and no activities conducted which, either alone or in combination with other wastes or activities, will cause turbidities to exceed those allowed by specific water quality criteria; provided, short-term activities necessary to accommodate essential dredging, channel or bank alterations, stream diversions or other construction where turbidities in excess of the criteria are unavoidable, may be authorized by the department under conditions as it may prescribe.

(h) Methods of sample collection preservation and analysis used to determine compliance with the standards are to be in accordance with the latest edition of Standard Methods for the Examination of Water and Wastewater published by the American Public Health Association or in accordance with tests or procedures that have been found to be equally or more applicable.

(i) For operations of existing water impoundments that cause conditions harmful to prescribed beneficial uses of state waters, it is to be demonstrated to the satisfaction of the department that continued operations will be done in the best practicable manner to minimize harmful effects that will not violate state laws or department rules. New water impoundments shall be designed to provide temperature variations in discharging water that maintain or enhance the existing propagating fishery and associated aquatic life. As a guide, the following temperature variations are recommended: Continuously less than 40°F during the months of January and February, and continuously greater than 44° F during the months of June through September.

(j) Ponds for waste treatment purposes are not to be located in drainage ways where the volume of drainage water from a 10-year storm entering the ponds exceeds one-half the volume of the pond; provided that, subject to approval by the department as to design and maintenance, ponds located in drainage ways for the express purpose of containing emergency oil spills are permitted.

(k) Dumping of snow from municipal and/or parking lot snow removal activities into waters of the state is prohibited without a permit from the department.

(l) Existing discharges to state waters will be entitled a mixing zone as determined by the department.

(m) Until such time as minimum stream flows are established for dewatered streams, the minimum treatment requirements for discharges to dewatered receiving streams are to be no less than the minimum treatment requirements prescribed.

(n) Treatment requirements for discharges to intermittent streams are to be no less than the minimum treatment requirements prescribed.

(o) Pollution resulting from storm drainage, storm sewer discharges, and non-point sources, including irrigation practices, road building, construction, logging practices, overgrazing and other practices, are to be eliminated or minimized as ordered by the department.

(p) Application of pesticides in or adjacent to state waters is to be in compliance with the labeled direction, and in accordance with provisions of the Montana Pesticides Act (Title 27, Chapter 2, R.C.M. 1947) and the Federal Environmental Pesticides Control Act (Public Law 92-516). Excess pesticides and pesticide containers are not to be disposed of in a manner or in a location where they are likely to pollute state waters.

(q) The following radiological criteria shall apply to all waters except those classified as A-Closed:

(i) The average dissolved concentrations (including the naturally occurring or background contribution) of iodine 131, radium-226, strontium-89, strontium-90 and tritium are not to exceed the following concentration limits:

Iodine-131	5 pCi/L
Radium-226	1 pCi/L
Strontium-89	100 pCi/L
Strontium-90	10 pCi/L
Tritium	3,000 pCI/L

For all other radionuclides, the average dissolved concentration limits are to be 1/150 of the corresponding maximum permissible concentration in water for continuous occupational exposure as recommended by the National Committee on Radiation Protection (National Bureau of Standards Handbook 69 or subsequent revisions).

(ii) For a mixture of radionuclides, the following relationship is to be satisfied:

$$\frac{C_1}{L_1} + \frac{C_2}{L_2} \cdot \cdot \cdot + \frac{C_n}{L_n} \qquad 1.00$$

C denotes the average concentration of the respective radionuclides, and L denotes its concentration limit.

(iii) Where alpha emitters, strontium-90, radium-228, iodine-129, iodine-130 and lead-210 are known to be absent, routine analyses for dissolved gross beta radioactivity (excluding potassium-40 contribution) may be employed to monitor and show compliance with this criterion (except for tritium) as long as the gross concentration does not exceed 100 pCI/L. When these conditions are not met, routine quantitative analyses of individual radionuclides are to be performed to show compliance. Except in cases where tritium from other than natural sources is known to be absent, routine tritium analyses are to be performed to show compliance. (Note: "Absence" means a negligibly small fraction of the specific concentration limit, where the limit for unidentified alpha emitters is taken as the limit for radium-226).

(iv) For radionuclides associated with suspended material in transport, the average concentration limits are to be 1/150 of the corresponding maximum permissible concentration in water (insoluble form) for continuous occupational exposure as recommended by the National Committee on Radiation Protection. In-stream sedimentation of these materials is not to produce solids beds that are not in compliance with subsections (q) (i) and (q) (ii) (because of leaching) and/or excessive accumulation in native flora and fauna.

(v) Average concentrations are to be computed from monitoring data acquired during the previous 12 months; maximum concentrations are not to exceed three times the average concentration limits specified.

(vi) Variances from concentration limits specified will be permitted only if the contributing source is non-controllable or a natural source. Best available treatment must be provided for man-made discharges, and the exposure received by affected population groups must be within established dose limits.

(r) No wastes are to be discharged and no activities conducted which, either alone or in combination with other wastes or activities, will result in the dissolved gas content relative to the water surface to exceed 110 percent of saturation.

(s) Bioassay median tolerance concentrations are to be based on latest available research results for the materials, by bioassay tests procedures for simulating actual stream conditions as set forth in the latest edition of Standard Methods for the Examination of Water and Wastewater published by the American Public Health Association, or in accordance with tests or analytical procedures that have been found to be equal or more applicable by EPA. Bioassay studies are to be made using the most sensitive local species and life stages of economic or ecological importance; provided other species whose relative sensitivity is known may be used when there is difficulty in providing the most sensitive species in sufficient numbers.

When specific application factors are not available, the factor is to be determined by using methods listed in Water Quality Criteria published by the Federal Water Pollution Control Administration (1968), or by using other methods accepted as equal or applicable by EPA.

(t) Metal limits for the Clark Fork River (mainstem) from the confluence of Warm Springs Creek to the confluence with Cottonwood Creek are:

Material	Average Daily Concentration ug/l	Maximum Instantaneous Concentration ug/l
Total copper	90	180
Dissolved copper	30	40
Total zinc	300	1,000
Dissolved zinc	80	140
Total iron	1,300	2,200
Dissolved iron	150	160
Total lead	100	100
Dissolved lead	100	100
Total cadmium	10	10
Total arsenic	10	16
Total mercury	1	1

Metal limits for Clark Fork River (mainstem) from the confluence of Cottonwood Creek to the Idaho state line are:

Material	Average Daily Concentration ug/l	Maximum Instantaneous Concentration ug/l
Total copper	50	90
Dissolved copper	30	30
Total zinc	100	200
Dissolved zinc	70	80
Total iron	300	1,300
Dissolved iron	150	150
Total lead	50	50
Dissolved lead	50	50
Total cadmium	10	10
Total arsenic	10	10
Total mercury	1	1

(History: Sec. 69-4814, R.C.M. 1947; AMD, Order MAC No. 16-2-5; Adp. 7/13/73; Eff. 11/5/73; MAC not. No. 16-2-3; PRIOR P. 16-375 through 16-394.)

APPENDIX C

GLOSSARY

Symbol	Definition
BOD_5	Five-day biochemical demand
cfs	Cubic feet per second
gpcd	Gallons per capita per day
gpd	Gallons per day
gpm	Gallons per minute
JTU	Jackson turbidity unit
lbs/capita/day	Pounds per capita per day
lbs/day	Pounds per day
ml	Milliliter
mgd	Million gallons per day
mg/l	Milligrams per liter
sq. ft.	Square feet
TR	Total recoverable
tpd	Tons per day
μmhos	Micromhos per centimeter
$<$	Less than
$\leq$	Less than or equal to
$\geq$	Greater than or equal to
$\sim$	Approximately
BPT	Best practical treatment
WQB	Montana Department of Health & Environmental Sciences, Environmental Sciences Division, Water Quality Bureau
F & G	Fish and Game, Montana Department of
MDHES	Montana Department of Health & Environmental Sciences
MPDES	Montana Pollutant Discharge Elimination System
NPDES	National Pollutant Discharge Elimination System
BuRec	Bureau of Reclamation
EPA	U. S. Environmental Protection Agency
NOAA	National Oceanographic and Atmospheric Administration
SCS	U. S. Department of Agriculture, Soil Conservation Service.
USGS	U. S. Geological Survey
USPHS	U. S. Public Health Service

APPENDIX D

DISCHARGE PERMITS AND COMPLIANCE SCHEDULES

FACILITY	NPDES OR MPDES PERMIT NO.	DATE ISSUED	EXPIRATION DATE	COMPLIANCE SCHEDULE
Valley Vu Feedlot Fairview, Montana	MT-0022268	12/31/74	10/31/79	none
Reuben Schroeber Terry, Montana	MT-0022721	12/31/74	10/31/79	none
Yellowstone Livestock Co. Sidney, Montana	MT-0023574	12/31/74		none
Tenderloin Industry, Inc. Sidney, Montana	MT-0028126	not issued yet		
C. E. Cattle Co. Miles City, Montana	MT-0022772	12/31/74	10/31/79	none
Lucky Charm Dairy Glendive, Montana	No permit required - no discharge			
Lower Yellowstone Irrigation Dist. No. 1	Application under review			
Lower Yellowstone Irrigation Dist. No. 2	"			
Savage Irrigation District	"			
Intake Irrigation District	"			
Savage Sewage Lagoon, Savage, Montana	no permit required (no discharge)			
Fallon Sewage Lagoon, Fallon, Montana	no application received			

FACILITY	NPDES OR MPDES PERMIT NO.	DATE ISSUED	EXPIRATION DATE	COMPLIANCE SCHEDULE
Lambert Sewage Lagoon, Lambert, Montana	No permit required (no discharge)			
Sidney Sewage Lagoon, Sidney, Montana	MT-0021849	12/13/73	1/1/77	No schedule of compliance
Fairview Sewage Lagoon, Fairview, Montana	MT-0023019	6/14/74	12/31/76	Yes, date not specified
Miles City Sewage Lagoon, Miles City, Montana	MT-0020001	12/13/73	7/1/77	Secondary Treatment by June 1, 1976
Terry Sewage Lagoon, Terry, Montana	MT-0020117	11/21/73	7/1/77	Secondary Treatment by July 1, 1977
Glendive Sewage Lagoon Glendive, Montana	MT-0021628	12/13/73	7/1/77	Yes, date not specified
West Glendive Sewage Lagoon Glendive, Montana	MT-0021733	11/21/73	7/1/77	Yes, date not specified
Broadus Sewage Lagoon, Broadus, Montana	MT-0022110	12/13/73	7/1/77	Secondary Treatment by July 1, 1977
Belle Creek Sewage Lagoon Belle Creek, Montana (Gary Operating Company)	MT-0022501	12/13/73	7/1/77	Secondary Treatment by July 1, 1977
Baker Sewage Lagoon, Baker, Montana	MT-0022381	7/24/74	12/31/76	Yes, date not specified
Plevna Sewage Lagoon, Plevna, Montana	MT-0021776	9/16/74	12/31/76	Yes, date not specified

FACILITY	NPDES OR MPDES PERMIT NO.	DATE ISSUED	EXPIRATION DATE	COMPLIANCE SCHEDULE
Shell Oil Company, Cabin Creek	MT-0000311	3/19/74	1/1/76	none
Sidney Rendering Plant, Sidney, Montana	No permit required (no discharge)			
MDU Generating Plant, Sidney, Montana	MT-0000302	6/14/74	9/30/76	none
Holly Sugar Co., Sidney, Montana	MT-0000248	7/31/73	7/1/75	none
Glendive WTP, Glendive, Montana	MT-0000876	12/13/73	9/30/76	BPCT by January 1, 1976
Miles City Packing Co., Miles City, Montana	No permit required (no discharge)			
Miles City Sand and Gravel Co. Miles City, Montana	No application received			
Rahr Meat Co., Glendive, Montana	No permit required			
MDU Generating Plant, Glendive, Montana	MT-0000299	2/18/75	6/30/74	none
Gary Operating Co., Belle Creek, Montana	15 discharges 4 permits not issued yet	10/31/73	12/31/75	Yes, dates variable
Union Texas Petroleum Co., Belle Creek, Montana	MT-0020320	1/3/75	6/30/76	none
Union Texas Petroleum Co., Glendive, Montana	Permit application just received			